HANDBOOK

OF THE

MECHANICAL ARTS

CONCERNED IN

THE CONSTRUCTION AND ARRANGEMENT OF DWELLING-HOUSES AND OTHER BUILDINGS

WITH

PRACTICAL HINTS ON ROAD-MAKING AND THE ENCLOSING OF LAND

BY

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PREFACE.

THE issue of a new Edition has afforded the Author an opportunity of greatly extending the scope and design of the Work. Originally prepared for the exclusive use of COLONISTS and EMIGRANTS, the various departments were treated of in such a way to simplify to the utmost all the details of arrangement and construction; and the consideration of many important subjects was for obvious reasons altogether excluded. From the interest which the Work excited, the idea was suggested to the Author of so adding—should opportunity offer—to the subjects treated of, as to adapt it for a wider circle of readers than that for which it was originally compiled. This opportunity has now been afforded, and advantage has been taken of it to add several new sections, thoroughly remodel the whole Work, and to secure for it all the advantages which a profusion of illustrations can give. Much, however, of the original design has been retained, in order still to adapt it to the Colonist or Emigrant.

PREFACE.

Although fully aware of the shortcomings of the Work, the Author nevertheless ventures to trust that, from the variety of subjects treated of, and the numerous drawings with which its pages abound, it will in some degree be useful, not only as a text-book for the student, but as a guide to the emigrant settler abroad, and the practical man in this country.

February 25, 1860.

HANDBOOK

OF THE

MECHANICAL ARTS.

SECTION FIRST.

HOUSE ARRANGEMENT AND CONVENIENCES.

In detailing our plans and suggestions on this important department, we have considered it best to make them as complete as our limits would admit of, in order that structures arranged accordingly, may contain, in a comparatively complete state, the requisites essential to insure to the inhabitants a high degree of comfort, health, and convenience, so far as these can be obtained by structural arrangements. We endeavour to offer as high a standard as possible, leaving it to the reader to act up to or modify it, as his convenience or notions may dictate.

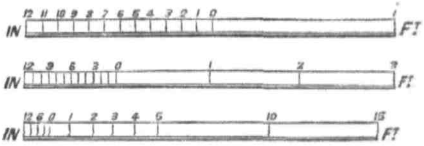
Before giving the "plans" of the various classes of houses suitable for all conditions of the emigrant settler's life, we shall explain the meaning of various terms used while describing plans of houses, &c. By the term "elevation" we mean the view obtained of a house or other object, when the spectator is standing directly in front of every portion of it. In the case of a house there are various elevations—as, the direct view of the front is termed the "front elevation"—the view of the end, the "end"—and of the back the "back elevation." Thus fig. 42 is a front elevation. A "section" is a view of any part of an object, obtained by cutting off a certain part,

exposing the interior arrangement. Thus, when an orange is cut down the centre, the front view of one-half shows the section and interior arrangement. In houses, sections are of two kinds—"transverse" or "longitudinal." In the former, the cutting line is taken across the breadth of the building; in the latter, along the length. It is evident that a section may be taken through any point of the plan of a house, showing the disposition of the timbers, position of doors, &c., according to choice. "A plan," properly speaking, is a horizontal section; the view of the arrangement of walls, windows, partitions, doors, and fireplaces, being obtained by cutting the house throughout its whole extent by an imaginary line, parallel with the ground, at a short distance above the level of the ground. The peculiar features of a ground-plan will be seen on inspection of fig. 43. Plans are of various kinds—as "ground," showing the arrangement of apartments in the ground floor; "chamber plans," show the arrangements of bedroom floor. A plan of this kind is seen in fig. 44, which is the bedroom floor of cottage, of which fig. 43 is the ground floor.

The sizes or dimensions of the apartments given in a plan properly drawn are ascertained by means of "a scale." In this country, our colonies, and the United States of America, all plans of houses are generally drawn to scales of feet and inches; the divisions in the "rules," according to which the scales are calculated, being 12 inches in a foot, and eight divisions in an inch, called "eighths." Supposing the plan of a house, of which the apartment measured 18 feet by 12, was required to be delineated on paper, it is evident that it would be impossible to have paper large enough to take on its surface the extent of 18 feet by 12; but suppose it was arranged that the space of an actual foot was to be denoted on the paper by the extent of one actual inch, the 18 feet would then be represented by a distance of 18 inches, and the 12 feet by 12 inches. Again, supposing that the size was 18 feet 6 inches by 12 feet 9, as the feet are denoted by inches, as agreed on, it will be necessary to give the inches a diminished size, in proportion to the feet. Now, as there are 12 inches in a foot, all that is necessary in the present case to be done is, to divide the inch (denoting a foot by arrangement) into twelve equal parts, each of which would denote

the space of an inch. Thus the actual size of the apartment, 18 feet 6 inches in length, would be denoted by 18 inches and 6 equal parts of an inch; and the breadth, 12 feet 9 inches, by 12 inches and 9 equal parts of an inch. This, then, is the rationale of scales. In the particular instance above noted, the house would be drawn to a scale of 1 inch to the foot: if ½ inch was agreed upon to be the sign of a foot, it would be a scale of ½ inch to the foot; if ¼ inch, ¼ inch to the foot, and so on. In fig. 1 we give a sketch of a scale of 1 inch, ½ inch, and ⅛ inch, to the foot. To take any measurement from a scale—as, say 1 foot 6—place one leg of the compasses in the point 1 in the large divisions to the right, and reach the other leg to the division 6 in the small divisions, denoting inches, to the left: the distance thus obtained in the compasses is 1 foot 6. Where a plan is given without the sizes marked, but the "scale" mentioned or affixed, the distance between any two sides of any apartment being taken in the compasses, the dimensions of full size may be easily ascertained by applying it to the scale. Thus, suppose one leg was in the point 12 of the large division to the right, denoting feet, and the other reached to the point 7 in the divisions to the left, denoting inches, the size of apartment would thus be shown to be 12 feet 7 inches. We have been thus particular in describing these points, being well aware that our work will fall into the hands of many to whom the "terms" would be as a "sealed book," and to whom the plans would be in a great measure useless, unless the means were presented of becoming acquainted with easy methods of understanding them.

Fig. 1.



We now proceed to give plans of various styles of edifices, the first we shall present being a cottage arranged in the simplest possible style. *A*, fig. 2, is the only room, which might be described best in the words of "the comedian," as serving for

"Parlour, kitchen, and—
Everything."

Entrance is obtained by the door *c* at once to the room; light is admitted by the one window *b*; the fireplace is at *d*. This arrangement should only be adopted at the first outset of the settler; and not even then, unless compelled by want of means, as it is notoriously unfitted as a healthy or convenient dwelling. The next diagram, fig. 3, is designed to show how the arrangement in fig. 2 can be advantageously modified. The outer walls of fig. 3 are extended to *o*, as in the sketch, and carried up to the level of the eaves; a flat-boarded roof, with waterproof covering, may be thrown over the extension; partitions are run across this extension, as seen; and the following conveniences are obtained: A separate sleeping apartment *B* is obtained, entered from the living-room *A*; a closet *C*, containing at window a small slop-stone *n* and cupboard *n*. Entering from the end, the water-closet is obtained in the small space left. Cupboards *e e* may be easily constructed at each side of the fireplace—(see JOINERY). In fig. 4 we give a sketch of an arrangement containing two rooms, in point of convenience being on a par with the one-roomed cottage in fig. 2. In fig. 4 the living-room *A* is approached through the door *f*, leading from the passage *e d*, and is lighted by a window in front, *h*. A bedroom *B* is provided, entering from the living-room *A*, and lighted by a window at *n*. Inasmuch

Fig. 2.

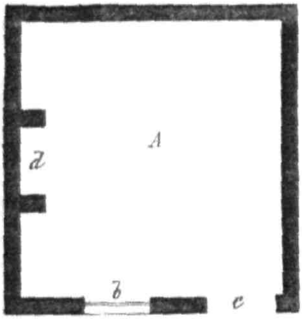
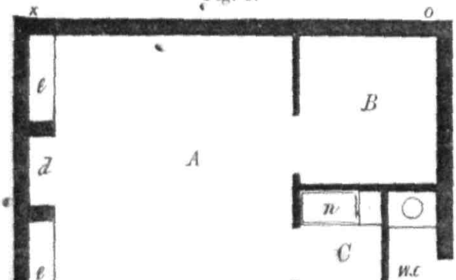


Fig. 3.



as the living-room is not entered from the exterior at once, and a bedroom is provided, this arrangement is an improvement on that given in fig. 2. It is, however, deficient in labour-saving conveniences. Fig. 5 details an arrangement which will cost little more than the house in fig. 4, yet containing those conveniences so highly desirable. The living-room *A* is lighted by the window *h*; the fireplace *r* is placed opposite the window, thus giving facilities for having a fireplace in the bedroom *B*, the flue running up alongside with that of the fireplace in *A*; or the bedroom may be warmed by one of the methods we shall hereafter describe. The passage *d*, in fig. 4, is made wider in fig. 5, thus affording space for a porch, entered from the exterior by the door *e*, containing a cupboard *o*; space also for a scullery, provided with a slopstone *n* and shelving, entered from

Fig. 4.

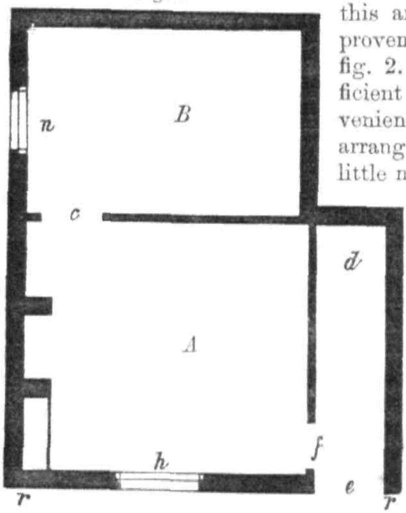
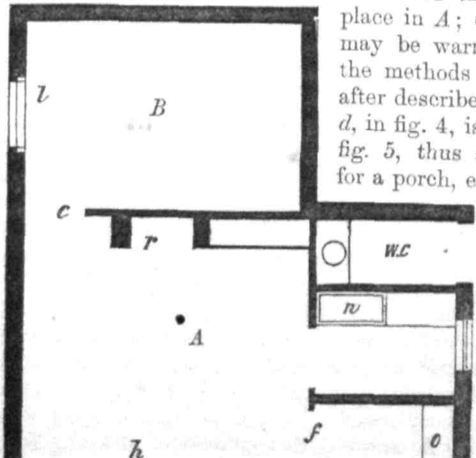


Fig. 5.



the living-room *A*. This closet is lighted by a small window, below which it might be advisable to place the slop-stone, instead of the situation we have given it in the sketch; more light would be thus afforded in carrying on the operations necessary. A water-closet is obtained in the space left at the extreme end, and entered as seen in the sketch. A rain-water cistern might be placed above the water-closet, a liquid-manure tank below it, into which the slops from the scullery may be led.

In these examples, the desideratum of having a distinct entrance to the bedroom has not been attained. In fig. 6 this has, however, been noticed in the arrangement. In this example, the projection *b a*, corresponding to that in fig. 5, is thrown back, so as to make the external wall of the water-closet be in a line with the back wall of the house. The entrance is at the side at *e*, the porch being large enough to form a pleasant small sitting-room in summer-time. The sitting-room *B* and bedroom *A* are both approached by separate doors, as in the sketch. A small scullery is entered from the former, lighted by a small window *c*, and supplied with slop-stone and shelving *d*. On the other side of porch a small wardrobe closet *h* is obtained, entering from bedroom *A*; a coal-place *v*, and water-closet, entering from end of house.

Fig. 6.

In fig. 7 we give an illustration of a mode of enlarging a single-roomed cottage, retaining the original walls. Let *a b* be

Fig. 7.

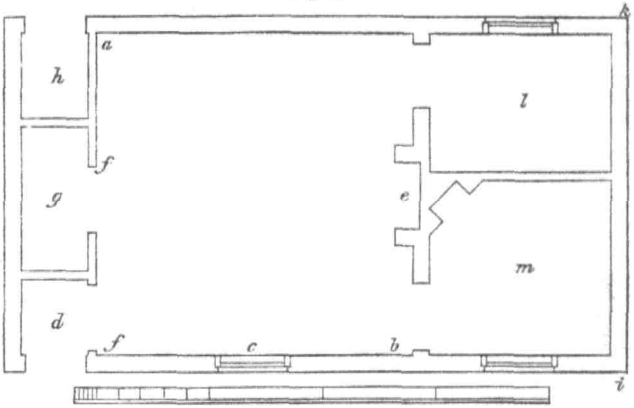
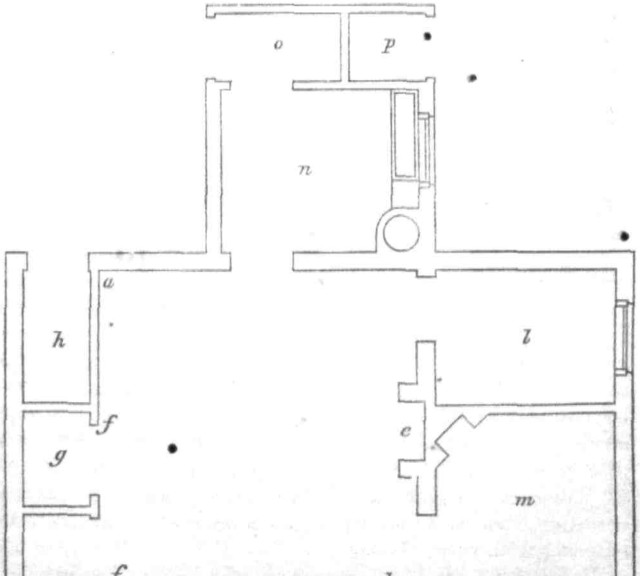


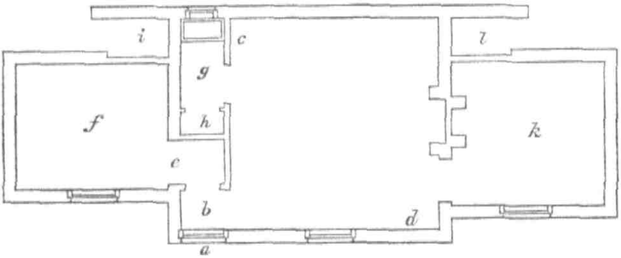
Fig. 8.



the room; *c* the window, *d* the entrance-door, and *e* the fire-place. By running up a partition *f f a*, space can be had for a porch *d*, a closet *g*, and a coal-place *h*. Extending the walls to *i k*, a small kitchen can be obtained at *l*, and a bedroom at *m*.

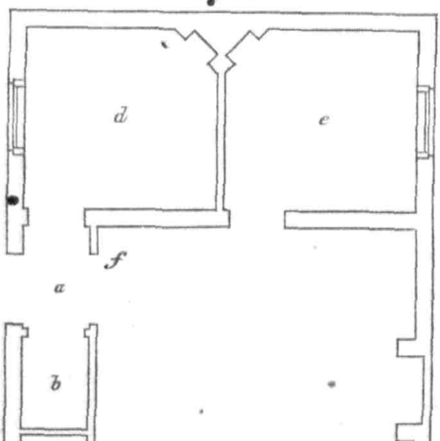
Fig. 8 shows another arrangement of same cottage—an

Fig. 9.



offset being made at the back, by which a scullery *n* is obtained, with coal-cellar *o*, and wood or lumber store *p*. The other apartments are the same, and denoted by the same letters as fig. 7, with the exception of *h*, which in fig. 8 is made a hen-house. Another arrangement is shown in fig. 9, in which two wings are added to the cottage, giving the following accommodation: *a* the entrance-door, *b* porch, *c d* living-room, *e* entrance to bedroom *f*; *g* scullery, with small closet *h*; *i* coal-cellar, *k*

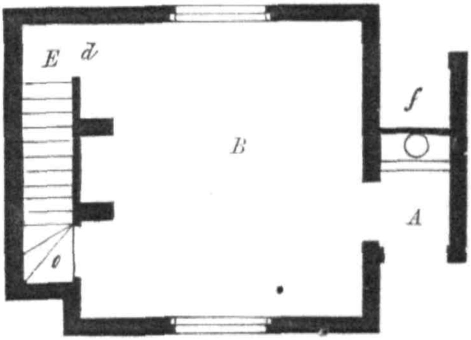
Fig. 10.



second bedroom, *l* hen-house. Fig. 10 shows another arrangement of same cottage. The entrance is changed to *a*; closets are obtained at *b* and *c*; *d* is a back-kitchen, *e* a bedroom, *f g* the living-room.

In these examples we have confined ourselves to cottages of one story; we now proceed, in like manner, to consider the arrangement of two-storied structures. In fig. 11 we give a simple arrangement, the bedroom floor of which is identical with the ground floor, with the exception of the projection containing the porch, &c. The living-room *B*

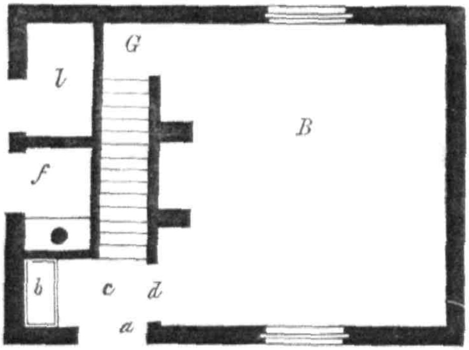
Fig. 11.



is lighted by two windows, the fireplace being at the end. *A* is the porch, giving shelter to the entrance-door to living-room *B*; *f* is a water-closet, entering from back of porch. Access is gained to bedroom above *B*, the sitting-room, by stairs *E*, entered from living-room by the door *d*. A door at the other side of fireplace gives admittance to a small closet *o*, beneath head of stairs, in which a small slop-stone is placed. For a married couple without family, or a gamekeeper, we consider this arrangement may possess many advantages. By running up the walls of porch, &c., a small chamber entering from bedroom may be obtained, of size sufficient to hold a child's bed. In fig. 12 we have detailed an arrangement by which more accommodation is obtained at the outlay of very little more material, and by which access is gained to the bedroom without passing through the living-room. Entrance is gained to the porch *c*, containing slop-stone *b*, by the external door *a*; *d* is the entrance to living-room *B*; *G* a small closet entering from living-room, placed beneath head of stairs. A water-closet is obtained at *f*; and, by continuing wall to

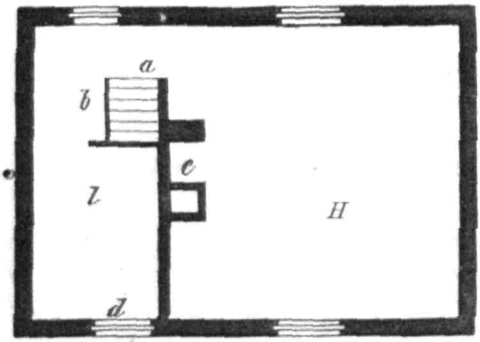
meet back wall of house, a space for coals may be obtained at *l*, a partition being made between it and the water-closet.

Fig. 12.



In fig. 13 we give sketch of bedroom plan of same cottage. *H* is the bedroom above the living-room *B*, with fireplace *c*. A small bedroom *l* is obtained by boarding over part of the staircase, leaving room to go easily under it in ascending or descending the stairs. This small bedroom is lighted by a window *d*, entered from the landing *b*; *a* is the entrance to the front bedroom *H*. The landing-place *b* is lighted by a small window. In fig. 14 we give a sketch illustrative of a suggestion for front elevation of this cottage. It is adapted to be built in pairs, the wall opposite fireplace in living-room *B* (fig. 12) being division wall between the cottages.

Fig. 13.



In fig. 15 we give the ground-plan of a two-storied cottage, adapted to be built in pairs, of a still better class than last given. The entrance is at *b*, the stairs *h h* leading to the bedroom floor. *A* is the living-room, *C* a scullery provided

with slop-stone; if necessary, a boiler may be fitted up in corner nearest fireplace of living-room. Entrance is gained to

Fig. 14.

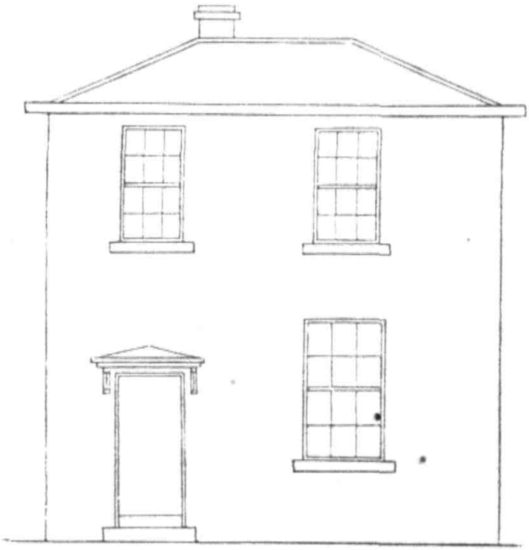
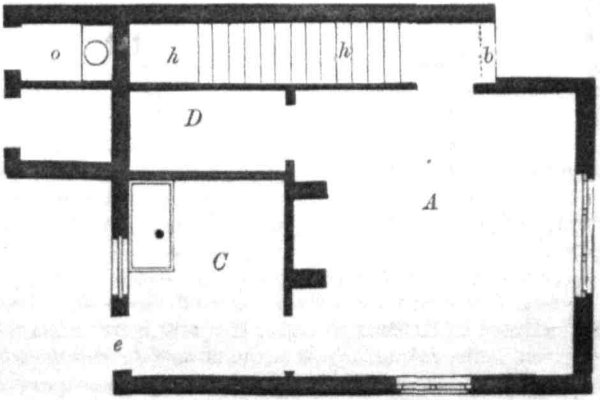
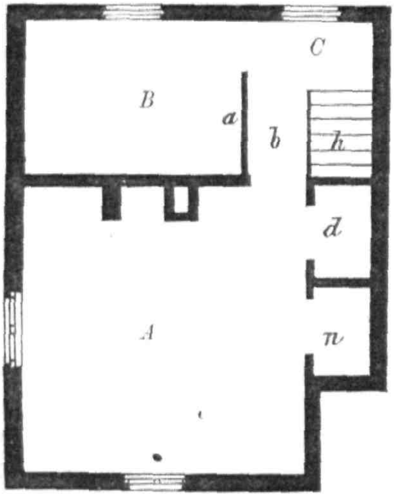


Fig. 15.



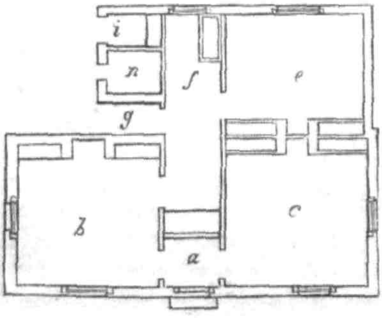
back-yard by the door *e*. *D* is a larder or store-closet entering from living-room *A*; if necessary, it may be continued under the head of stairs at *h*. The water-closet is at *o*, a receptacle for coals being next it. In fig. 16 the bedroom plan of this arrangement is given. *A* is the front bedroom, with two linen-closets or wardrobes, *n* and *d*, entering from it. *B* is back bedroom above the scullery *C*; a partition *a* separates it from the landing *b*; the landing is lighted by window at *C*. If necessary, a bedroom for children can be added, by running up the walls of water-closet, &c., entering it by door placed at the window *C*; the landing may be lighted by a small skylight above. All the sketches are drawn to a scale of $\frac{1}{8}$ inch = 1 foot.

Fig. 16.



In fig. 17 we give the plan of a one-storied cottage. The lobby or porch *a* is 5 feet wide; the living-room *b* 12 feet 6 inches by 11 feet 2, two cupboards being fitted up, one at each side of fire-place. The front bedroom *c* is of same size as living-room, the back bedroom *e* being 12 feet 6 inches by 9 feet 6; *f* is the scullery, *g* back passage,

Fig. 17.



n coal-place. In fig. 18 we give an alternative plan, showing how the example may be enlarged, so as to obtain an additional bedroom *E*, the back passage being at *c*; *A* is the living-room, *B* the front, and *C* the back bedroom; *d* is the scullery. In fig. 19 we give the front elevation of this example, and in fig. 20 the end elevation, drawn to a scale of $\frac{1}{8}$ inch to 1 foot: figs. 17 and 18 are drawn to $\frac{1}{16}$. In fig. 21 we give another plan of a one-storied cottage, drawn to a scale of $\frac{1}{16}$ inch to the foot. The living-room is entered through the scullery, independent entrances being obtained to the bedrooms as in last example. The living-room *c* is 12 feet square; a small china closet *e* is entered from it. The scullery *b* is 9 feet 6 inches; the front bedroom *d* 12 feet by 11, the back *f* 12 feet by 8:

Fig. 18.

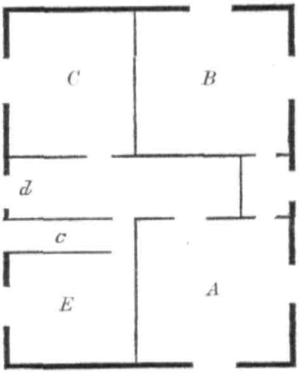
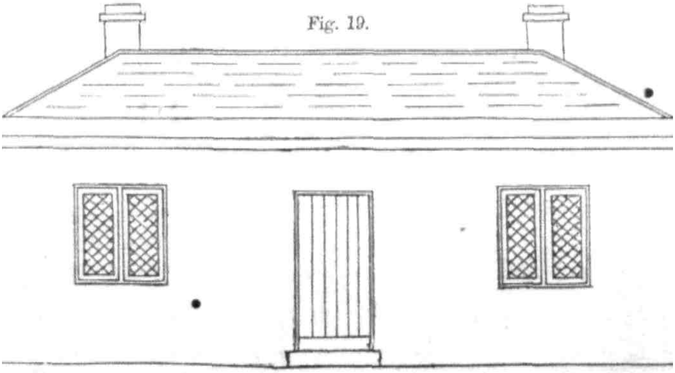


Fig. 19.



a is the entrance-door, *g* the water-closet. In fig. 22 we give front elevation, and in fig. 23 back elevation of this example, drawn to a scale of $\frac{1}{8}$ inch to the foot. In fig. 24

we give an arrangement of a single-roomed cottage, showing the manner of accommodating two beds in it:—" *a* is the door

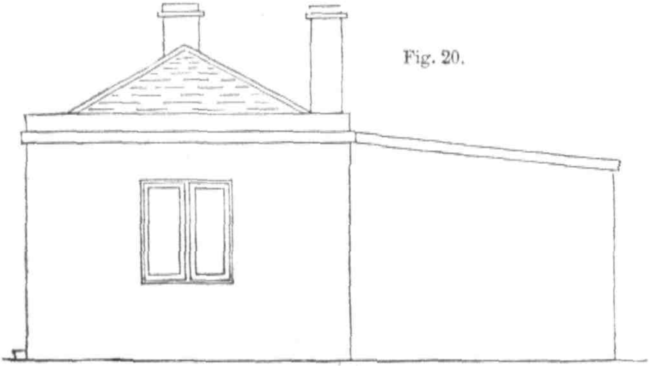
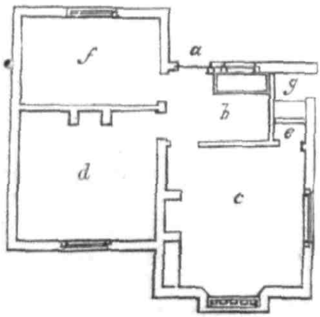


Fig. 20.

of entrance, *b* the porch, *c* the door into the room *d*; *e* is the fireplace, *f* the window of the room, *g* the plate-rack for holding the crockery, &c.; *h* the dresser; *i* and *k* are the two beds—*i* entering from the room *d*, and *k* from the small room *n*, provided with a window, which is divided by a partition between this room and the store-room *l*, which is entered from the porch by the door *m*. The apartment *n* has a door hinged on the corner of the bed *k*, if a box-bed, and on the wall if not so. If the beds are box-beds, which is the most common form, the inmates at night will be sufficiently separated, the married couple entering the bed *i* from the apartment *d*, and the field-worker, *k* from the small chamber *n*. Should the beds be of the tent-bed form, with curtains, farther separation might be effected by a wooden partition between the two beds, and at the ends of *k* next *l* and *d*, and at the back of *i* next *l*. Such a cottage measures 22 feet in length, and 15 in breadth—giving the floor

Fig. 21.



of *d* a space of 15 feet by 11½, which is enough for three adult persons." In fig. 25 an arrangement is given by which three beds can be accommodated in one room:—"*a* is

Fig. 22.

Fig. 23.

the entrance-door, *b* the porch, *c* the door of the apartment *d*; *e* the fireplace, *f* the window of the room, *g* the

plate-rack, *h* the dresser; *i m n* are three beds, so arranged that *m* enters from the room *d*, *i* from the small closet entered by the door *l*, and having the window *k* divided between it and the store-room *o*, which is entered by the passage *p*, where is a door, and has a bed in it, *n*. Box-beds would make a complete separation of their occupants by being so arranged. Tent-beds would require wooden partitions to separate *m* from *n*; and *i* would require one along the back next *p*, and at the end next *o*." In fig. 26 an arrangement is given with living-room and bedroom attached:—"*a* is the entrance-porch, 3 feet 3 inches by 4 feet 9; *b* the apartment, 15 feet by 14, with a window; *c* the bedroom, 10 feet square, with a window; *d* a light pantry, 4 feet 9 inches by 6 feet 6; *e e* are fireplaces, 4½ feet by 3½; and *f* a wall-press 3 feet wide. One bed can stand against the back wall of *b* for the hind and his wife, and another, if required, for two children; and one

Fig. 24.

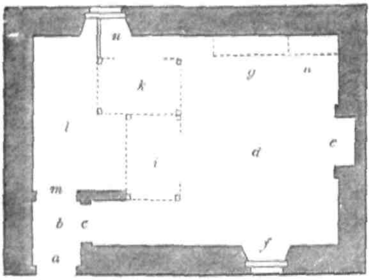


Fig. 25.

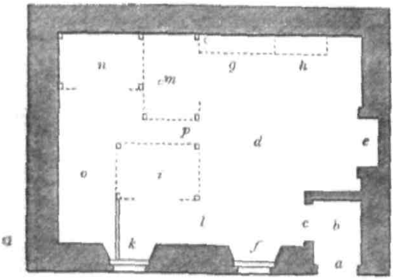
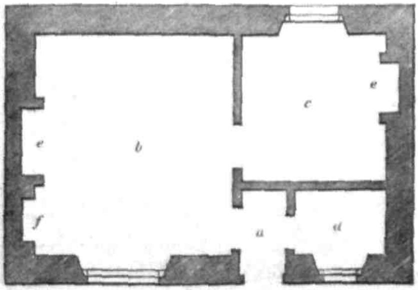
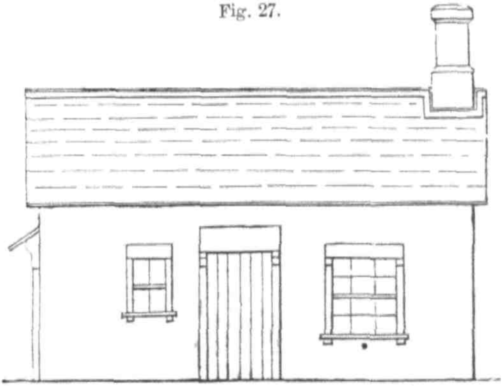


Fig. 26.



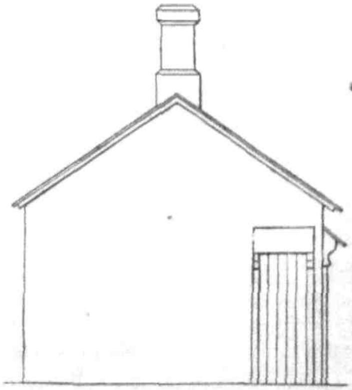
bed might be put into the room *c*, for the field-worker, and another for two children, if required. Thus three adult persons can well be accommodated in such a house, along with four children, if required." For these excellent suggestive plans we are indebted to Mr Stephens' elaborate work, *The Book of the Farm*.

Fig. 27.



In fig. 27 we give a design for a front elevation of the cottage of which we have given the plan in fig. 3, and in fig. 28 the end elevation. In fig. 29 we give the front elevation, and in fig. 30 the end elevation of cottage, the plan of which is in fig. 5. In fig. 31 the front elevation, in fig. 32 the end elevation, and in fig. 33 the back elevation of cottage, the plan of which we have given in fig. 6. These are all drawn to a scale of $\frac{1}{8}$ inch to the foot. In arranging a house, the obtaining a large supply of light should be well con-

Fig. 28.



sidered. Good aspect for the rooms in which the inhabitants spend most of their time, is of great importance; but it is very evident that all advantage in this respect is completely lost, if due means are not taken to allow the light to

Fig. 29.

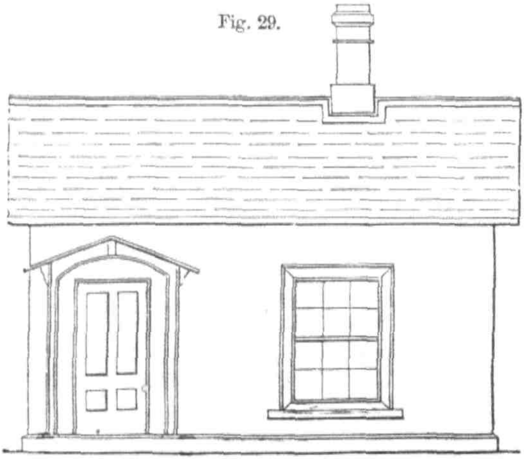
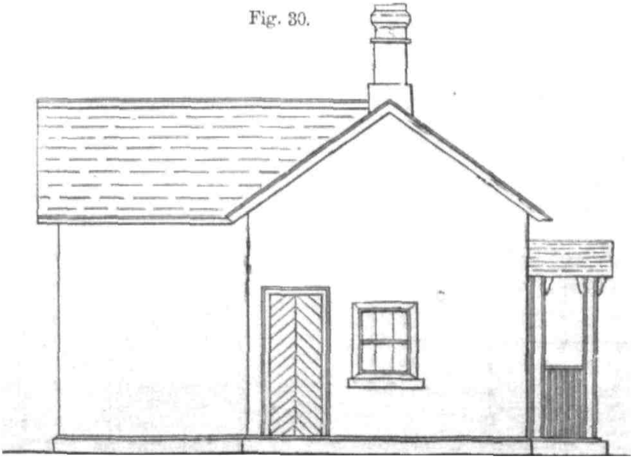


Fig. 30.



have unlimited access to the rooms. The importance of a good supply of light has been long overlooked, and it has only been within a very recent period that the subject has at all been considered. The result of the investigations on light

Fig. 31.

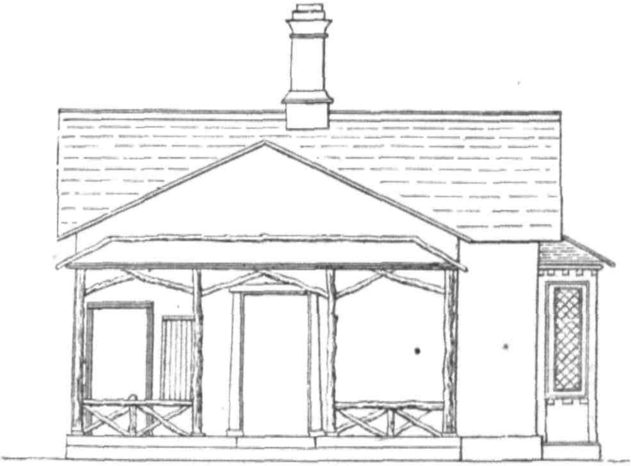
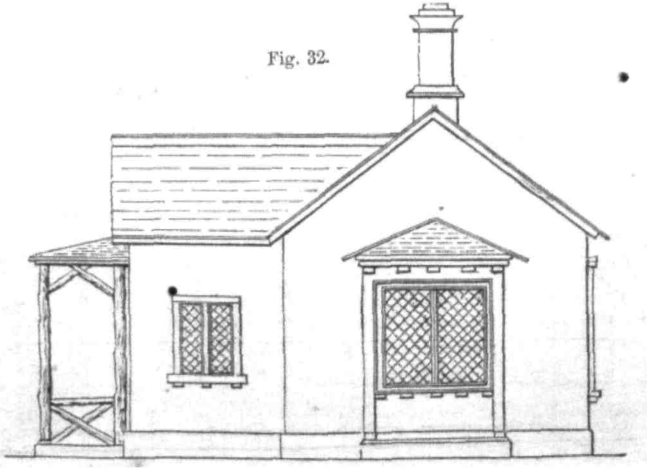
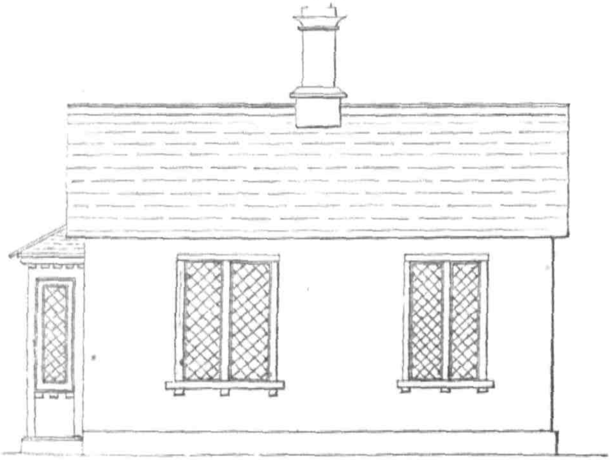


Fig. 32.



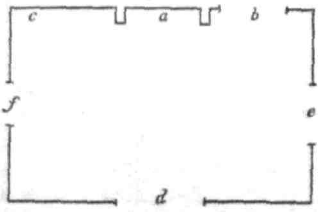
has proved that a close and intimate connection exists between it and the performance of the higher functions of animal and vegetable existence. A light room is more likely to be kept clean than a dark one. The more dark corners you have,

Fig. 33.



the greater amount of "filth and dirt." The window-sill in the sitting-room should be within 18 inches of the floor. A high sill darkens the aspect of the room. In the kitchen and scullery, the sills will require to be 2 feet 9 inches from the floor, to admit of the dresser and the slop-stone being placed against them. The arranging of windows with relation to fireplaces is of considerable importance. Not far from the place we write, there has been a large house lately constructed, in which the following absurdity has been perpetrated. In fig. 34, *a* is the fireplace, *b* the window; the corner *c* is so dark that the articles in the cupboard there placed can scarcely be seen in clear weather; in thick or misty, they are nearly altogether invis-

Fig. 34.



ible. But another, and even worse, fault is to be found with this arrangement. The fireplace, from the deep jambs, is thrown quite into the shade; and the result is, that all cooking processes are carried on with great difficulty and loss of time. If the window had been placed at *d*, the fault would not have been so egregious as in the former case, yet bad enough in some respects, as the cook would be standing with her back to the light; and if the window had an aspect favourable to the sunlight's easy entrance, the fire would be flooded with the light, and easily put out. The best position for the window would be *e* or *f*. Entrance-doors should not be placed on a level with the surrounding ground, but approached by one or more steps. This will throw the floor above the level of the ground and prevent damp rising, which should always be attended to in good constructions. The hanging of doors should be carefully considered. Where the door is in a corner of the room, the hinges should be at the side nearest the wall, so that the door when open will lie along the wall. When in the centre of the room, the door should be so hinged that, when open, the light from the window shall fall on its outer face. On a party entering the room, he cannot only see, but he can also be seen by, those in the apartment; if, on the contrary, it is hung the other way, on the door being opened the party entering is thrown into shade. Where a door communicates with a small room—as a closet, dressing-room, or bath-room, entering from a large room—the door should always open into the latter, there being too little space in the small one. If possible, the entrance to the living-room should be made through a porch or inner passage. This will keep the room much warmer in cold weather, than if entrance is obtained as in fig. 2, immediately from the external air. It is also the best arrangement, where bedrooms are placed on the same floor with the living-room, &c., that independent entrances should be obtained to them—thus avoiding the necessity of passing through the living-room when access is required. In cases of sickness the value of this arrangement will be appreciated. The kitchen should have, if possible, a small scullery attached to it, in which washing, &c., can be carried on. A small copper or boiler, with the furnace, having an independent flue, placed in the scullery, will be

a great convenience. An ash-pit should be provided in the yard, or back of building next to the water-closet, provided with a door through which the ashes can be passed. The ash-pit should in all cases be covered over, and the door made to fit tightly, so as to prevent the escape of effluvia from any decomposing substances placed in it. No liquid should be passed into the ash-pit, all of it being made to pass to the cesspool from the slop-stone, or soil-pan of the water-closet. With respect to conveniences — as cupboards, &c., for storing the multifarious utensils, &c., usually required in a house—it may be taken as a rule, that the more there are of these the better. We never yet knew of a house in which the housewife considered she had too many; the reverse is the rule. Internal cupboards—that is, placed neither against an external wall, nor within too close a propinquity to the fireplace—are exceedingly useful for keeping preserves, and such-like matters in, as they are neither too damp to mould, nor too hot to dry them up. With regard to storage-places for meat, and quickly perishable articles, it is essentially necessary that these should be cool. We are decidedly in favour of having an under-ground apartment or cellar, however small, for this purpose. The original cost is comparatively trifling, and the advantages derived from it very great. In the district in which we now write, it is calculated that a large saving is effected in domestic arrangements during the summer months by having under-ground cellars. So highly are they appreciated, and their value understood, that a cellar to a house is a *sine quâ non*. All kinds of eatables are much better kept in a separate apartment. The cellar should be provided with a stone slab of considerable dimensions, raised from the floor, on which to place meat, milk, &c. If a cellar or under-ground pantry is considered too expensive, a small safe should be made in a recess in the wall of the kitchen: this may project outwards from the wall, which may tend to keep the interior cooler.

We conclude this section by giving a few illustrations of the arrangement of what have been called "composite cottages"—that is, cottages of two stories, but of which the upper is a separate house having a distinct entrance. In fig. 35 we give the upper story of cottage, of which we have given the ground-plan in fig. 7. Entrance is gained by the

Fig. 35.

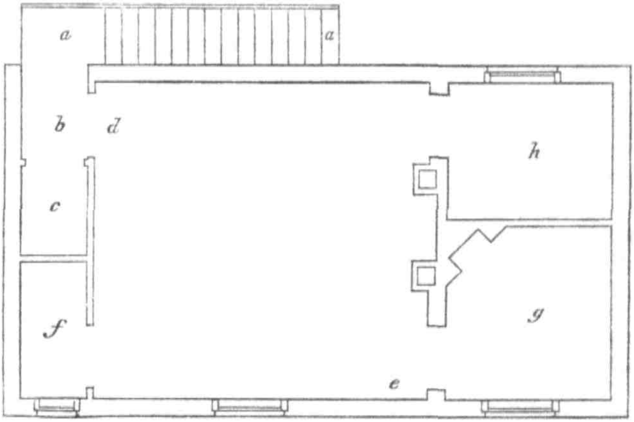
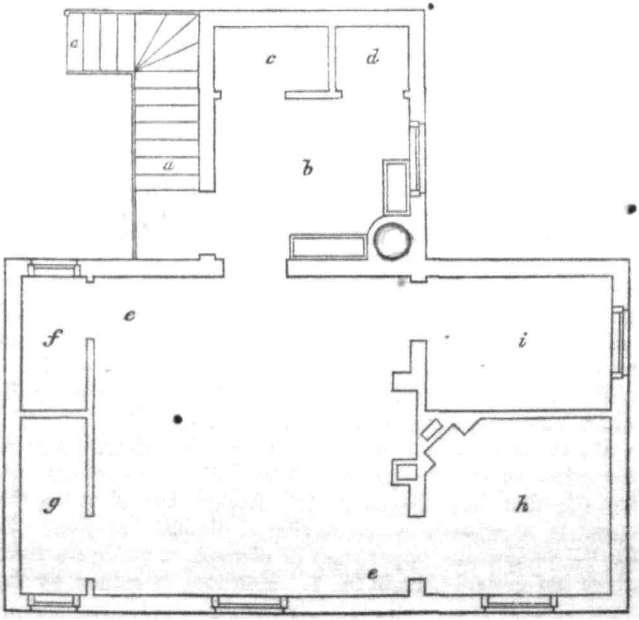
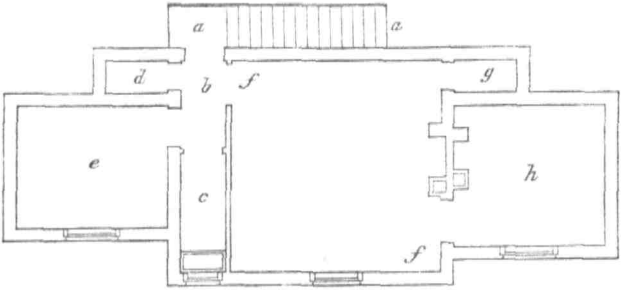


Fig. 36.



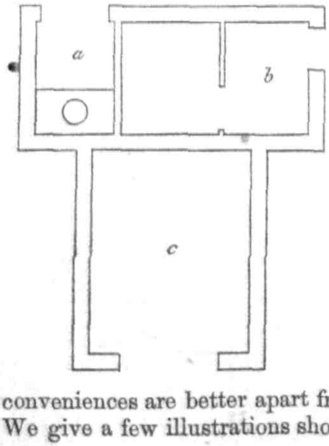
outside stairs *a a*; *b* porch, *c* closet, *d e* living-room, with light closet *f* off it; *g* bedroom; *h* ditto, or scullery. In fig. 36 we give the arrangement of upper story of cottage, of which in fig. 8 we have given the ground-plan. Entrance is gained by the outside stairs *a a*; *b* the scullery,

Fig. 37.



with store-closet *c*, and coal-place *d*; *e e* the living-room, with closets *f* and *g*; *h* and *i* bedrooms. In fig. 8, to admit of the outside stairs being placed as shown in fig. 36, the hen-house *o* will have to be entered at the end in place of the side of the house, as shown in fig. 8. In fig. 37 we give the arrangement of upper story of cottage of which we give ground-plan in fig. 9: *a a* outside entrance-stairs, *b* porch, *c* scullery, *d* coal-place, *e* bedroom, *f f* living-room, *g* closet, *h* bedroom. All these figures are drawn to a scale of $\frac{1}{8}$th of an inch to the foot.

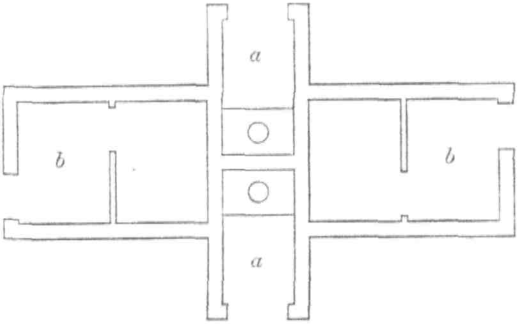
Fig. 38.



In several of the plans of the cottages which we have given, water-closets or privies are drawn as forming an integral part of the plan. There can be no doubt that these conveniences are better apart from, than when near the house. We give a few illustrations showing arrangements of separate

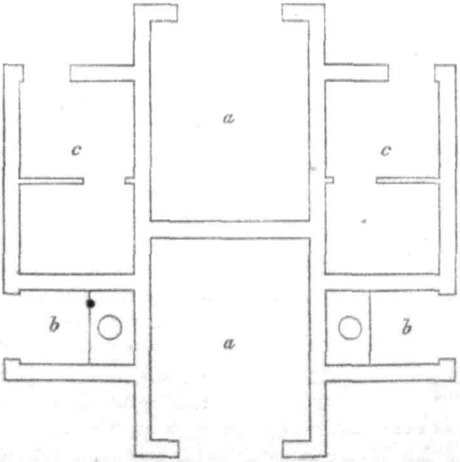
buildings, placed say at the foot of the garden. In fig. 38 we show an arrangement for a detached cottage: *a* the water-closet, *b* the pig-sty—if necessary, a cow-byre or shippen *c*

Fig. 39.



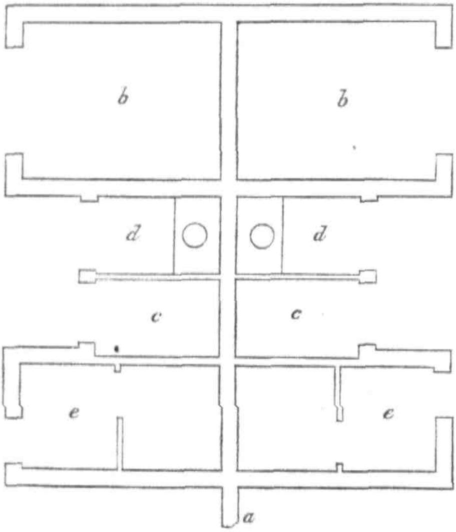
may form part of the building. In fig. 39 we give an arrangement suitable for two cottages: *a a* the water-closets, *b b* the pig-sties. In fig. 40 an arrangement is given

Fig. 40.



for two cottages, with cow-byres *a a*; *b b* privies, *c c* pig-sties. In fig. 41 we give another arrangement, where *a* is the dividing wall between the two cottages, *b b* the cow-houses, *c c* hen-houses, *d d* water-closets, *e e* pig-sties.

Fig. 41.



SECTION SECOND.

BUILDING SPECIFICATIONS—BILLS OF QUANTITIES AND ESTIMATES.

UNDER the above title we propose to furnish the reader with practical examples, which will serve as a guide in drawing up the important documents of Specifications, Bills of Quantities, and Estimates. It is considered unnecessary here to detail the value attached to carefully drawn-up papers of the above nature: as documents to which constant reference is made during the progress of the works, and which define exactly the nature of the agreements entered into between the contracting parties, and the basis on which these agreements are founded, it must be obvious that much of their value depends on the way in which they are drawn up.

A Specification may be divided into three parts: 1st, The Title; 2d, The Conditions of Contract; 3d, The Description in detail of the Work to be performed. The language of a specification should aim at being thoroughly explicit—neither tautological or full of repetition on the one hand, nor so concise or scanty as to lead to ambiguity or doubt on the other. The chief point to be attended to is the arrangement of the departments of work to be described, so that a ready reference can be made to any portion in which information is required. In specifications of large works, each distinct clause is numbered and pointed out by a "marginal reference;" while, still further to make reference easy, a full detailed Index is sometimes added. The following may be taken as a fair specimen of a specification adapted for works not very extensive in their character:—

TITLE.

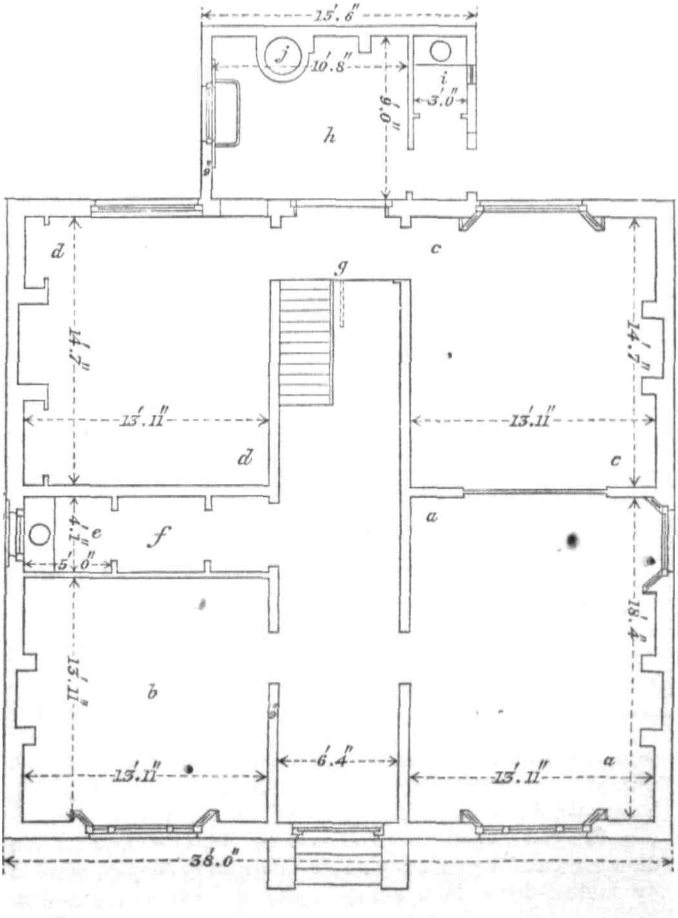
Specification of the several works to be done, and materials to be employed, in the erecting and finishing a new dwelling-house and offices for —— ———, Esq., according to the drawings, provided and numbered as follows, and as prepared for that purpose by —— ———, architect :—No. 1 (fig. 42), front elevation; No. 2 (fig. 43), ground-plan; No. 3

(No. 1) Fig. 42.

(fig. 44), chamber plan; No. 4 (fig. 45), cellar plan; No. 5 (fig. 46), plan of flooring-timbers of first floor; No. 6 (fig. 47), longitudinal section; No. 7 (fig. 48), back elevation; No. 8 (fig. 49), end elevation. (*Note.*—In fig. 43, ground-plan: *a a* dining-room, *b* breakfast-room; *c c* parlour or library, divided by folding-doors from dining-room; *d d* kitchen, *e* water-

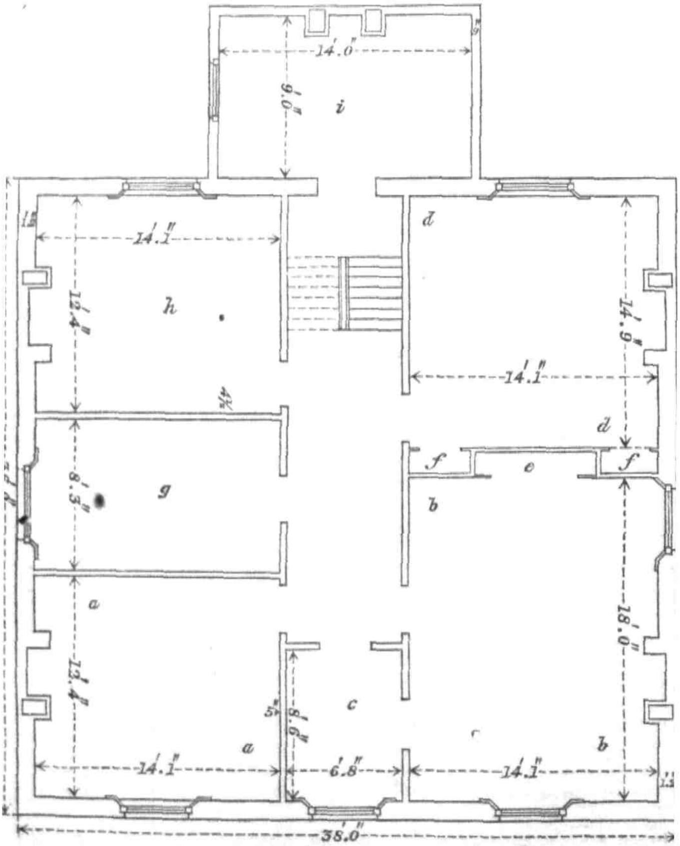
closet, *f* hats, *g* stairs; *h* scullery, with boiler *j*; *i* servants' water-closet. In fig. 44, chamber plan: *a a* bedroom; *b b* principal ditto, with dressing-closet *c*, and wardrobe-closet *e*; *f f*

(No. 2) Fig. 43.

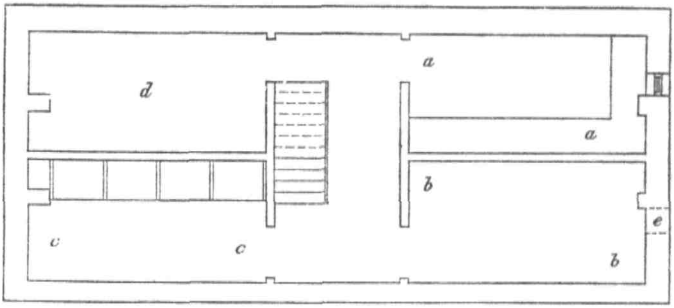


closets from back bedroom *d d*, *g* bed-closet, *h* bedroom, *i* servants' bedroom. In fig. 45, cellar plan: *a a* beer-cellar; *b b* coal ditto, with "shoot" *e*; *c c* wine-cellar, *d* store-cellar for potatoes, &c.)

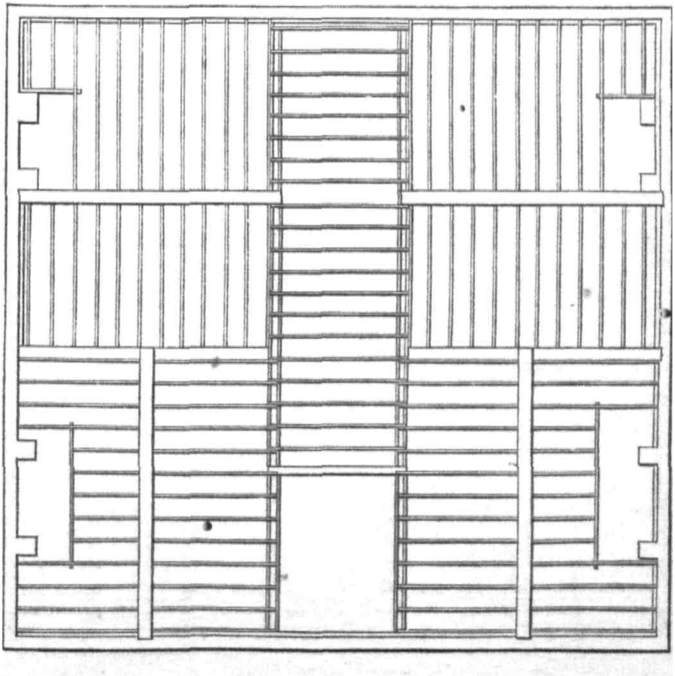
(No. 3) Fig. 44.



(No. 4) Fig. 45.

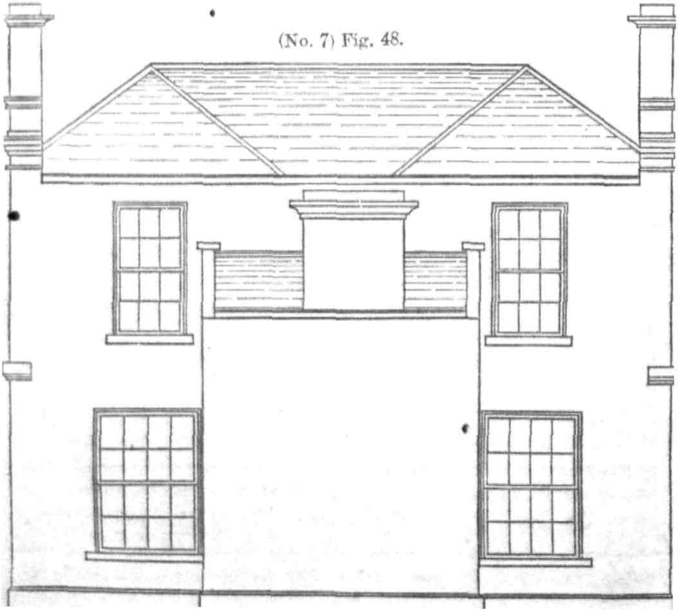


(No. 5) Fig. 46.



(No. 6) Fig. 47.

(No. 7) Fig. 48.



(No. 8) Fig. 49.

GENERAL CONDITIONS.

1st. The Drawings and Specifications must be taken together to explain each other; but should there be any work or materials, usually considered necessary to complete the works, not shown on the drawings or described in the specification, or that are mentioned or explained in either only, the Contractor must include the same in his tender as if the same had been more particularly described and delineated, and, generally, must find and supply whatsoever may be wanting to complete the different works, according to the true intent and meaning of the specification and drawings; and any doubtful or disputed question, arising on this or any other subject, is to be decided by the Architect, whose decision in writing shall be binding, or without appeal.

2d. From the commencement to the finishing of every part of the respective works, the care of the same, and whatever appertains thereto, is to be with the several Contractors, who are, each in his respective department, to protect and preserve the same; and in the case of any damage or injury happening to any part of the intended works, by the Artificers employed, by malicious and wilful destruction, by theft, by

the inclemency of the weather, or by fire, or any accident whatever, the Contractor or Contractors whom it may concern shall repair the same at his or their cost, so that at the conclusion of the several works every part of the works may be complete and perfect; and the Proprietor is not to be chargeable for anything lost, stolen, damaged, or destroyed.

3d. The Proprietor reserves to himself, through his Architect, the right of making any alterations or additions in the several works as they proceed, without multiplying or invalidating the contract—the value of such alterations or additions to be ascertained by the Architect, in which case the Contractor is to deliver to him or the Clerk of Works a statement every day of the time and materials used for such addition; and, in default of the same, such extra charge will not be allowed and paid for, or such extra works shall be previously contracted for as the Architect may deem fit, and the amount to be paid or deducted as the case may be. But it is to be understood that the Proprietor will not feel himself bound by any orders which may be said to have been given verbally for any such alterations or additions; and consequently no allowance will be made for any such works, except the Contractor can produce a written order to that effect signed by the Architect.

4th. It shall be in the power of the Architect or Clerk of Works to reject, and cause to be removed, any part of the materials or workmanship which either or both of them may consider improper and unworkmanlike, upon first giving the Contractor two days' notice in writing to that effect; and in case the Contractor shall refuse or delay to rectify the same, or refuse to comply with the orders so given to him in writing, or shall perform all or any part of the work in an improper manner, or in case the works do not proceed with proper despatch, then, in all or any such cases, the Proprietor shall have power and be at full liberty to suspend the further execution of the works by the said Contractor, after having given six days' notice to that effect, to take it out of his hands and employ and engage any other person or persons, subject to the terms of the original contract, to perform and execute, and find fit and proper materials for the same. In which case the costs and charges thereof shall be paid or allowed to the Proprietor by the original Contractor or his Sureties, or

deducted or retained out of the money which may be his due, or which may become due to the said party.

5th. The works are to be commenced immediately after the signing of the contract, and the whole to be entirely completed on or before the —— day of ——, one thousand eight hundred and ——, or the Contractor is to forfeit and pay the sum of —— shillings per day for each and every day exceeding the date herein stated, until the entire completion of the several works.

6th. The payment to be made in instalments of —— each, payable at such times as the Architect shall consider the Contractor has sufficiently completed and exceeded work to that amount by £20 per cent.

7th. The building, from the commencement to the finishing thereof, and the materials placed on the land, are to be considered in the possession of the Proprietor, without tending to make void or invalidating any of the foregoing conditions, or making him liable to risk or damage of whatsoever description; and the Contractor is to deliver the buildings up to the Proprietor, at the completion of the works, in a clean and perfect condition.

8th. The figures are, in all cases, to be preferred when they differ from the drawings; and the Contractor is to keep in a box on the ground a copy of the whole of the contract, drawings, and specification, which may at all times be accessible to the Workmen or Architect.

9th. The foregoing Specification and Contract apply only to the house as shown by the drawings. The garden and yard-wall, privies and ash-pits, front and back gates, stabling, or other outbuildings and works, not being included herein.

10th. Provide £50 for contingencies, which sum is to be appropriated at the discretion of the Architect. Any part of the above provisions not required is to be deducted from the contract sum.

Excavator.

Make all necessary excavations for cellars, areas, footings, walls, chimney-jambs, piers, footings for partitions, fenders, pipes, drains, &c. required, and shown by drawings. Draw off all water, and remove

Excavations.

Draw off water, &c.

all the soil that may come into the excavations from springs, drains, rain, or other cause whatsoever, and effectually complete the drainage of the excavations before any brickwork is carried up, and shore up the ground as may be required. Level and ram down hard, the beds of all footings, and consolidate the earth about same, and also against all walls, drains, &c.

Consolidate the earth.

Lay under the external walls round building, a course of good lime-concrete, mixed in the proportion of one part of Blue Lias, Dorking, or other approved stone-lime, and five parts of clear dry gravel (the large stones or flints being broken), or Thames ballast, 1 foot wider than the lowest course of footings, and 18 inches deep. Throw the concrete into the trenches from a stage at least 6 feet above their level.

Concrete. Concrete thrown in.

Remove all superfluous soil, and all rubbish that may have accumulated at the conclusion of the works, and leave all clean and perfect to the satisfaction of the architect.

Remove soil, &c.

Bricklayer.

Stock brickwork.

The brickwork to commence on the concrete, the first course being laid and bedded in mortar.

The whole of the brickwork, as shown on plans, to be constructed with the best hard, well-burnt, sound stock-bricks, laid English bond, and to be carried up regularly. The mortar to be composed of one-third well-burnt Dorking, or other approved stone-lime, and two-thirds of sharp, clean, river or other approved sand or road grit, free from salt, the whole to be well laboured. No four course of the work to rise more than $\frac{3}{4}$ inch beyond the collected height of the bricks; every course to be filled in and fully flushed up with mortar; and grouted with liquid mortar of hot lime and sand every second course below level of ground floor, and every fourth course above. No variation to be made between the inside and outside work; the joints inside throughout to be left rough, to form key for plastering. Lay all round the walls under ground-floor joists, a double

Mortar. Grouting. Joints, &c.

course of Countess slates, the whole width of brick-work breaking joints and to be bedded in cement. Turn 9-in. relieving arches over all lintels and brest-summers. Turn to all fireplaces, where required, $4\frac{1}{2}$-in. brick trimmers in cement, to have a butment of York stone to project 2 in. to receive same. Build, where required, 9-in. ground fenders with two course of footings. Properly form all fire-openings with camber arches over the same, with chimney-bars of wrought iron $3 \times \frac{1}{2}$-in. and 18 in. longer than chimney-openings, properly cogged at the end to fire-places, on all the floors. Carefully gather in the chimney-throats, and carry up flues of not less than 14×9 in. in the clear, well pargeted with well-laboured cow-dung pargeting. Bring out in cement all projections for string-courses, &c., as shown on elevations, and bed-courses of 2-in. rough York core, where necessary, for cornices, mouldings, &c. Bed in mortar all bond timber, plates, lintels, wood-bricks, templates, and other wood-work required to be set on the brickwork; bed and point round all window and door frames with lime-and-hair mortar, and bed the sash-sills with white-lead. Cut all splays, skew-backs, chamfers, &c., where required.

Course of slates in cement. Relieving arches. Trimmers. Fenders. Chimney-bars. Flues pargeted. Bedding and pointing.

Pave the scullery and larder with stock-brick paving in mortar, to be jointed in cement. Pave the wine, beer, and coal cellars with hard bricks on edge in mortar, on a good and firm prepared bottom. To form chimney-heads in cement, and provide and fix in cement, chimney-pots of approved pattern; set in tiles, and cement. Build up half-brick standards to support sink and York shelves, and wine-bins. Form a 7-in. circular tile-pipe drain from scullery and water-closets to run into sewer, the joints being made of well-tempered clay. Make good the necessary openings into sewer, and form proper dip-traps in cement, and carefully work round soil-pipe in cement. Set the copper, and all stoves and grates, with fire-bricks.

Brick paving. Chimney-pots. Wine-bins. Drains, &c. Stoves set.

To work in the iron hooping provided by smith as directed; to work in under ground-floor joists 16 cast-iron air-bricks. The bricklayer to provide proper

Iron hooping.

Scaffolding. scaffolding to carry up the work, to attend on the masons, plumbers, carpenters, smiths, aiding and Jobbing. making good after them, and perform all jobbing necessary to the carrying out of the works; and to leave all in a perfect state at completion.

Mason.

Door-steps. The steps to front door to be $2\frac{1}{2}$-in. rubbed Portland stone; the top step to be mortised to receive door-posts.

Provide and fix to the windows throughout, Portland stone weathered sunk and throated sills, 4 in. deep on face, and $4\frac{1}{2}$ in. on back edge, $8\frac{1}{2}$ in. wide, and 4 in. longer than the opening. To put to the fireplaces throughout back hearths of 2-in. tooled York stone; to the principal rooms on ground floor, front hearths of 2-in. rubbed Portland stone; and to the kitchen and bedrooms 2-in. rubbed York stone. Provide and fix to the ground-floor rooms marble chimney-pieces of the value of £5, 5s. To the two principal bedrooms, marble chimney-pieces, value £2, 2s., and to the smaller bedrooms, Portland boxed chimney-pieces, value 25s. Provide and fix to the kitchen and scullery plain Portland mantel, jambs, &c., 9 in. wide.

Sills. Front hearths. Chimney-pieces, &c.

Sink. Provide and fix in scullery a 6-in. York-stone sink, with hole cut for pipe and rounded corners. Fit up the wine-cellar with two tier of 2-in. York shelves, supported on brick standards. Cope the side-walls to outbuilding with 3 in. York coping, 11 in. wide, well bedded in cement, throated both sides, and with proper plug-holes run with lead. The chimney-pieces to be securely cramped. To cut all holes and notchings, provide all cramps, lead, cement, &c.; attend smith, and clean down all stone-work at finish.

Coping. Jobbing.

Carpenter and Joiner.

Timbers. The whole of the timbers to be used, to be good, sound, and well-grown Baltic, Dantzic, Riga, or Memel fir, of an approved quality, well seasoned and

free from sap-shakes, large or unsound knots; cut die square and true to the several dimensions and lengths shown in the drawings, and herein described; and no timber to be fixed more than 12 in. apart, or to have a less bearing than 6 in. on the walls.

The oak to be English growth, well seasoned, and cut die square. Oak timbers.

Provide and fix all necessary centring and turning pieces, stops, fillets, backings, blocks, firrings, bearers, and all other minor articles necessary to the perfect and efficient completion of the various works, described under the heads of bricklayer, mason, carpenter, slater, plasterer, joiner, and plumber. The centring to be eased and finally struck when directed by the architect. Scaffolding.

Provide all necessary wood-bricks, 2 feet 9 in. apart, to doors and windows, and upright ditto to skirting, 2 feet 6 in. apart, with every required preparation for firring grounds, battens, and joinery. Wood-bricks.

Provide and fix, good and sound fir-lintels over all doors, windows, and openings, generally within the brick-arched soffit—it being clearly understood, with respect to external doors and windows, that no lintel shall appear outside the head of the wood frame. The lintels to have a vertical depth of 1¼ in. for every foot opening, and a bearing of at least 9 inches at each end beyond the width of the opening, and the carpenter to see that the relieving arches before described are turned by the bricklayer. Lintels. Lay a tier of wall-plates under each floor of joists, 5 × 4 in., well scarfed and secured together in long lengths, and united at flues with an iron tie, 2½ × ½ in. Wall-plates. The joists to drawing-room, breakfast-room, and hall, on ground floor, and also to scullery, to be of fir, 4 × 2¾ in., on oak sleepers 4 × 3 in., laid on the sleeper walls, brought up to receive the same. Joists. The floors to dining-room and kitchen to have girders, 12 × 10 in., cut in two, reversed and bolted together, properly secured to oak templates 3 feet long, 6 × 4 in. Fir joists framed into girders, 7 × 2 in. Girders. The floors to bedrooms in main building to

be of same materials and scantling as to the dining-room and kitchen, but to have ceiling-joists framed and notched, 4 × 2 in.

The joists to landing, dressing-room, and bed-room, in outbuilding, to have fir joists 7 × 2½ in. Put all round walls of ground and first floor mid-story, a tier of bond, 4 × 2½ in., in the greatest lengths attainable, halved and spiked at angles, and returned to run through the several openings, and cut out when directed. Provide and lay to flat, fir-bearers to a proper fall, averaging 4 × 2 in., properly firred up to cause fall, with rough boarding over ditto, and necessary rounded rolls for lead-work.

Bond.

Bearers to Flat.

Roof.

The roof to be framed to the same pitch as shown on section; to have plates 5 × 4 in. returned, and secured with iron ties 2 × ½ in., through flues; angle ties, 4 × 3 in., dovetailed and notched; principal rafters, 8 × 3 in.; tie-beams, 9 × 3 in.; purlins, 7 × 3 in.; struts, 4 × 3 in.; rafters, 4 × 2½ in.; hip-rafters, 9 × 2 in.; ridge, 9 × 2 in.; ceiling-joists, 3 × 2 in.; ¾-inch iron king-rod, with cast-iron head, nuts, and bolt at bottom. The gutters to have 1¼-in. gutterboards, and bearers 3 × 2 in., with rebated drips and cesspools at vents; to be laid to a fall of not less than 1¾ in. to every 10 feet. To provide and fix all necessary feather-edged eaves, boards, tilting fillets, and springing pieces as required. Frame the quarter partitions on first floor, head, and sill, 5 × 4 in.; outer ditto, 5 × 4 in.; door-posts, 5 × 4 in.; braces, 3 × 4 in.; quarters, 5 × 2 in. Provide and fix over water-closet a cistern 4 feet long, 2 feet 6 in. wide, and 2 feet deep; to have 1½-in. deal, wrought, tongued, and beaded bottom and bearers, and 1½-in. deal wrought one side, and dovetailed rims. To provide and fix angle staves, &c., where required. To fix all iron-work in roofs, floors, &c. To provide moulds, trammels, and other necessary implements.

Gutters.

Quarter partitions.

Cistern.

Deals.

The whole of the joiner's work to be executed with the best well-seasoned yellow deals (except where white are specially described to be used); all to be taken as wrought and fixed, and not to finish less than one-eighth of an inch under the several thick-

nesses herein specified; to be free from sap-shakes, large and unsound knots, and no rough or cross-grained deals or battens to be used in any of the finishings. The making of the framing of the doors, sashes, &c., to commence on the signing of the contract, and to be left without wedging-up until the building is in a fit state to receive them. The mouldings to be worked true, clean, and accurately mitred, and the whole of the work to be put together in the best and most workmanlike manner. The timber of the floors to be furred up a quarter of an inch in all doorways, so that the doors, when open, may clear the carpets; and when shut, fit true and close. Lay the floors to hall, drawing-room, dining-room, and morning-room, with $1\frac{1}{4}$-in. yellow deals, not more than 9 in. wide, with close joints, splayed headings, and mitred borders, well nailed with three nails on every joist in each board, properly and truly cleaned off at completion. Lay the floors to kitchen and one pair, with $1\frac{1}{4}$-in. white deal, straight joint, splayed headings, and mitred borders, and nailed on edges. **Wedging-up.** **Floors.**

Windows generally. *Ground floor.*—The drawing-room, dining and morning room, to have 2-in. deal lamb's-tongue sashes, double hung, with best white lines and iron weights and brass axle-pulleys, glazed with best polished sheet-glass, and to have double-cased frames; oak double-sunk sills, wrought and weathered, finished with proper boxings. 1-in. deal bead butt linings, $1\frac{1}{2}$-in. deal 2-panel moulded front shutters on splay and in one height, and prepared to cut, hung with $2\frac{1}{2}$-in. butts and screws, and $1\frac{1}{4}$-in. deal back-flaps, hung with 2-in. strap hinges. $1\frac{1}{4}$-in. deal moulded backs, elbows, and soffits on splay, and finished with grounds and architraves to match doors. To be fitted with brass spring-roller sash, fastening to each window, and to each shutter two ebony knobs, and to have a 30-inch spring-plate shutter-bar complete. The water-closet window to have double-cased frame and $1\frac{1}{2}$-in. ovolo sash, single hung, with lines and weights. The kitchen window to be fitted with double-cased frames, to hang sashes and shutters, oak **Windows on ground floor.** **Shutter.** **Shutter furniture.** **Window, water-closet.** **Window, kitchen.**

sill, 2-in. ovolo sashes, hung with axle-pulleys, lines, and weights, glazed with seconds glass; the shutters to be of $1\frac{1}{2}$-in. deal, 3-panel bead butt, and square, hung with lines and weights, and secured with thumb-screw, and to have two flush lifting rings; to have 1-in. deal 1-panel moulded front. The windows to scullery to have double-cased frame, $1\frac{1}{2}$-in. ovolo sash, hung with lines and weights, and glazed with seconds glass, $1\frac{1}{4}$-in. rounded window-board, and to have $1\frac{1}{4}$-in. deal bead butt, and square shutters, hung with 2-in. butts and screws. The privy to be fitted with $1\frac{1}{2}$-in. small casement, glazed with seconds glass, and hung with 2-in. butts to wrought and rebated frame, 2 feet 6 × 1 foot 6 in. The light between scullery and staircase to have $1\frac{1}{2}$-in. ovolo sash, glazed with seconds glass, fixed to $1\frac{1}{4}$-in. ovolo sash, glazed with seconds glass, fixed to $1\frac{1}{4}$-in. deal wrought and rebated linings, hung on centres to ventilate the lower part of house.

Shutters, hung with lines and weights.

Windows, scullery.

Casements.

Borrowed light.

Doors generally. *Ground floor.*—The external door to Hall, to be $2\frac{1}{4}$-in. deal, 2-panel moulded inside, and bolection moulded outside, hung with $4\frac{1}{2}$-in. butts and screws to proper fir wrought rebated and beaded frame 4 × 4 in. Provide and fix a 9-in. draw-back lock, ornamented knocker, and bronze knob, a length of door-chain and barrel, and two 12-in. brass knob barrel-bolts to this door. Provide and fix over ditto in frame as before, a 2-in. moulded fanlight, glazed with one pane of polished sheet-glass, and provide and fix round the inside of the frame $\frac{3}{4}$-in. wrought and beaded staff-beaded linings. The doors to drawing-room, dining-room, and morning-room, to be $1\frac{1}{2}$-in. deal, 4-panel square moulded, both sides hung with 3-in. brass butts and screws to $1\frac{1}{4}$-in. double rebated jamb-linings, with 1-in. framed grounds and 8-in. moulded architraves on both sides. Provide and fix 7-in. brass mortise-locks and ebony furniture to these doors. The folding-doors between the drawing-room and dining-room to be 2-in. deal moulded, both sides hung with 4-in. brass butts and screws to each door; to have two

Front door.

Fanlight.

Doors, drawing and dining rooms.

Folding-doors.

12-in. brass flush-bolts, with brass eyes and rebated mortise-lock and ebony furniture complete. The architraves to match other doors. Provide to lobby to kitchen, and lobby to water-closet, $1\frac{1}{2}$-in. deal square framed sash-doors, with diminished styles and marginal squares, and glazed with ornamental ground glass, hung with 3-in. butts to framed rebated and beaded linings, and to be fitted with 6-in. brass mortise-locks. The water-closet to have $1\frac{1}{2}$-in. deal, 4-panel moulded inside, and bead butt door; hung with 3-in. butts and screws to $1\frac{1}{4}$-in. deal wrought, rebated, and beaded jamb-linings, and to be fastened with water-closet latch and private bolt. Fix over water-closet door a fanlight of $1\frac{1}{2}$-in. deal 4 feet × 4 feet, glazed with ground glass, and secured in rebated linings same as to door. The doors to kitchen and scullery to be $1\frac{1}{2}$-in. deal, 4-panel square doors, hung with 3-in. butts and screws to $1\frac{1}{4}$-in. deal, single, rebated, rounded, and staff-beaded jamb-linings, and to have 6-in. iron rim-locks.

Sash-doors.

Door, water-closet.

Doors, kitchen,&c.

The door leading to basement to be $1\frac{1}{2}$-in. deal, square framed sash-door, hung to $1\frac{1}{4}$-in. deal rebated linings, and to be fastened with a bow-latch fastener. The door to garden from scullery to be $1\frac{1}{4}$-in. deal, wrought and beaded proper ledged door, hung with $3\frac{1}{2}$-in. butts and screws, and to be fastened with thumb-latch and common barrel-bolts. Fit up in kitchen on each side of fireplace, the whole height of room, $1\frac{1}{4}$-in. deal, 6-panel beaded closet fronts in two heights, the doors hung with $1\frac{1}{2}$-in. butts and screws, and on each door brass knob and button and cupboard lock complete. The closets to have three tier of 1-in. shelves, on proper bearers, each shelf $1\frac{1}{2}$ in. narrower than that above it.

Proper ledged door.

Closet fronts.

Shelves.

Skirtings.—The drawing-room, dining-room, and morning-room, to have skirtings with $1\frac{1}{4}$-in. deal, rebated plinth 11 in. high, and rebated moulding 6 in. girt on top, and narrow skirting-grounds. The hall to have 1-in. deal, torus-skirting 9 in. high. The kitchen and scullery 1-in. deal square skirting 8 in. high.

Skirting to drawing-room.

To hall.

To kitchen.

Fittings to water-closets. Fit up the servants' water-closet with yellow deal, and the best water-closet with Honduras mahogany, seat and riser with mitred clamped flap and beaded frame, hung with 2-in. butts and screws; cut holes in seats for pans and pulls, beaded. Enclose the pipes, &c., from cistern above with $\frac{3}{4}$-in. deal wrought and beaded fir-casing secured to grounds. Put $\frac{3}{4}$-in. skirting $4\frac{1}{2}$ in. high round seats. (Pipe-casing.)

Dresser. Provide and fix in kitchen a dresser, 8 feet × 2 feet, with three drawers, pot-board, three shelves, cut standards, square legs, and moulded fascia complete: a drawer-lock to be put on one of the drawers, and wood knobs on all.

Staircase. *Staircases.*—To construct the staircase from ground floor to first floor with $1\frac{1}{4}$-in. yellow deal treads, glued and blocked, moulded and mitred return ends; and 1-in. deal risers on fir carriages, housed into $1\frac{1}{4}$-in. sunk and moulded wall-string; and $1\frac{1}{4}$-in. cut and mitred and staff-beaded outer string, with cut brackets to ends of steps. To have $2\frac{1}{4}$-in. moulded Honduras mahogany hand-rail, with $1\frac{1}{4}$-in. deal bar balusters dovetailed into treads, and a sufficient number of wrought-iron balusters to steady the rail; with cast-iron newel and curtail end to bottom step, and ramps, scrolls, &c., to hand-rail. (Hand-rail. Wrought-iron balusters.)

Provide and fix $\frac{3}{4}$-in. deal beaded fascia to the well-hole, with 1-in. deal rounded nosings on landings. The stairs to basement to have $1\frac{1}{4}$-in. deal treads and risers, with rounded nosings, housed into $1\frac{1}{4}$-in. deal plain wall and outer string; with deal moulded hand-rail, turned newel, and 1-in. square bar balusters, dovetailed. Enclose the side of staircase from hall to first landing with $1\frac{1}{4}$-in. deal moulded spandrel-framing. (Stairs to basement.)

Windows, one pair story. *Windows* generally—*One pair Story.*—The windows to all bedrooms in main building to have $1\frac{3}{4}$-in. deal lamb's-tongue sashes, hung with lines, weights, brass-faced pulleys, and to have brass-roller spring-sash fastening to each window, glazed with best seconds crown glass. To have deal-cased frames, oak double-sunk sills, wrought and rebated, finished

with 1-in. deal splayed and moulded linings; and moulded backs, elbows, and soffits, and a rim of ogee and bead moulding round, to form architrave.

The staircase-window to correspond with the bedroom ditto. The window to bedroom off landing, to have deal-cased frame and 1½-in. ovolo sash, hung with lines and weights, and fastened with spring-sash fastening. **Window on staircase.**

Doors generally—*One pair Story.*—The doorways to all the bedrooms and dressing-room to have 1½-in. deal 4-panel moulded, both sides square, framed doors, hung with 3-in. butts and screws to 1¼-in. deal wrought and rebated linings, with 1-in. framed grounds, 4-in. wide; and ogee and bead moulding to form architraves on both sides, and to be fastened with 6-in. brass mortise-locks. **Doors, one pair.**

Fit up the presses in best bedrooms with 1¼-in. deal fronts, and 1¼-in. deal 4-panel square doors, hung with 2-in. butts and screws, and fastened with small brass flush-bolts and cupboard-locks: to have 1-in. deal wrought top on bearers. Fit up the inside with four tier of 1-in. deal shelves on proper bearers. Put an ogee moulding round whole, to form architrave. **Press in bedroom.**

Fit up the closets of second best bedrooms with 1¼-in. deal cupboard fronts and doors, 1-in. deal top on bearers; 1-in. deal shelves on ditto; and ogee moulding round, to form architraves, and to be fastened with cupboard-locks. **Closets.**

Skirt all the bedrooms in main building with torus-skirting 9 in. high. The room off staircase, square skirting 7 in. high.

Basement generally.—Provide and fix to doorway of larder, 1½-in. deal 4-panel square door, hung with 3-in. butts and screws, to 1-in. deal rebated and rounded frame, the upper panels filled in with zinc, and to have iron rim lock. Fit up the larder with two tier of 1-in. deal shelves on bearers 11 in. wide, and 6 feet of meat-rail and hooks. **Doors to basement.** **Shelves to larder.**

Provide and fix to small window 1¼-in. deal casement, light hung, to solid rebated frame, and fastened with small barrel-bolts. Put to the coal, wine, and **Casement.**

beer cellars, $1\frac{1}{2}$-in. deal 4-panel square doors, hung with 3-in. butts and screws to $1\frac{1}{4}$-in. single rebated and rounded jamb. Put a 6-in. iron rim 3-bolt lock on each door, except the wine-cellar, which is to have a proper wine-cellar lock thereon.

SLATER.

Countess slates. To cover the roofs with the best countess slating on battens, with copper nails, and leave all perfect at close of the works.

Slate-cistern. Provide and fix in scullery a slate-cistern, put together with iron stays and copper bolts, to contain 250 gallons of water for the supply of the sink, kitchen-range, &c.

Slate-dresser. Provide and fix in larder, a 1-inch rubbed slate-dresser of width marked in plan.

PLUMBER.

Pipes and cocks. Supply the water, from the main to the cisterns, with 1-in. lead supply-pipe, and 1-inch ball-cock, balls, and bosses complete, and brass union joint to slate-cistern.

Provide a brass washer and waste to each cistern, with $1\frac{1}{2}$-in. waste-pipe complete.

Provide and fix 2-in lead funnel-pipe to sink, trapped into drain with brass grating and bell-trap to ditto. Lay on water from cistern to sink by $\frac{3}{4}$-in. lead supply-pipe, and put $\frac{3}{4}$-in. brass bib-cock to the sink; supply the boiler of range, from cistern in scullery, with $\frac{1}{2}$-in. supply-pipe, with a $\frac{1}{2}$-in. brass ball-cock and ball complete. Lay on from cistern, over closet, $\frac{3}{4}$-in. service-pipe to supply ditto.

Pipes and cocks.

Water-closet apparatus. Provide and fix in water-closet a best white pan apparatus, complete with D trap, service-box, valve, wires, pipes, &c., and 4-in. lead soil-pipe complete, trapped into the drain with 4-in. lead arm-pipe out of 6-lb. lead, properly fixed to same from the basin. Form a trap in drain with proper dip-stone. Line the cistern to water-closet with 5-lb. lead at sides and 6-lb. at bottom, well soldered at joints. Lay the gutters and flat with milled lead, 5 lb. to the foot

Trap to drain.

Lay the gutters.

superficial, turned up 9 in. under slates, and 6 in. against walls, and properly dress the same to all drips and rolls. Cover the hips and ridge of roof with 5-lb. lead, secured with lead-headed nails.

SMITH.

Provide (to be set by the bricklayer) the following stoves in bedrooms:—24-inch common bedroom grates, with cheeks complete; and in drawing-room, dining-room, &c., 3-feet register stoves with movable bright bars and black ones. Provide and fix in kitchen a 54-in. kitchen-range, with oven and boiler complete. Provide and fix in scullery a copper 2 feet in diameter. Provide and fix for each chimney-opening wrought-iron chimney-bars 3 × ½-in., properly turned up, and cogged at each end, to be 18 in. longer than opening. Provide all necessary rain-water pipes, with heads properly trapped into drain, to carry water from roof; and to back of house a run of 4-in. cast-iron eaves-guttering, the joints made water-tight with white-lead. Provide and fix to larder and coal-cellar window-opening, ¾-in. wrought guard-bars let into 2½-in. top and bottom plates, and built into brickwork. To provide 3 cwt. of iron hooping to be used as directed.

Bedroom stoves. Register stoves. Range. Chimney-bars. Rain-water pipes. Window-guards.

PLASTERER.

Externally.—Compo the whole of the external walls, and run the whole of the cornices, strings, mouldings, and dressings generally, with Greave's blue lias lime, mixed with clean sharp river-sand, in the proportion of two parts sand and one part lime—care to be taken that all arrises, mitres, mouldings, quirks, angles, &c., are to be cut clean, sharp, and true, and the several enrichments cast clean, and fixed firmly and accurately.

Externally in lias cement. Mouldings, &c.

Provide and fix accurately, eighteen cast cement balusters, and six half ditto.

Balusters.

Provide and fix two ornamental trusses to doorway 24 in. deep.

Trusses.

Internally.—The lime to be used for internal work

	@	£	s.	d.
Brought forward,		326	4	4
Labour and Materials Setting.	@			
7 Stoves, ...	7/	2	9	0
1 Large range, ...	18/	0	18	0
1 Copper, ...	25/	1	5	0
Remove all ground or rubbish that may have accumulated during the progress of the works, and leave all perfect, . .		1	5	8
Attend on, cut away for, and make good after all trades, ...		2	0	8
		£334	2	8

MASON.

In Portland Stone.

Ft.	in.		@	£	s.	d.
31	8	Superficial $2\frac{1}{2}$ in. rubbed steps and risers, .	2/	3	3	4
11	0	,, 2 in. jambs and mantel, . .	1/10	1	0	2
20	0	,, 2 in. rubbed slabs, ...	1/7	1	11	8
19	0	Run back joint, ...	/2	0	3	2
26	0	,, moulded edge, $3\frac{1}{2}$ in. girt, ...	/5	0	10	10
68	0	,, sills, $8 \times 4\frac{1}{2}$ in., ...	2/9	9	7	0
		4 Ends of steps and risers, pinned, . .	1/	0	4	0
		4 Mortise-holes, cut, ...	/3	0	1	0
		1 Portland boxed chimney-piece, including fixing,	25/	1	5	0
		3 Marble chimney-pieces, fixed, . . . £5	5/	15	15	0
		4 Do. do. do. . . . £2	2/	8	8	0

In Yorkshire Stone.

Ft.	in.		@	£	s.	d.
58	6	Superficial 2 in. rubbed slab, ...	/11	2	13	$7\frac{1}{2}$
36	10	,, 2 in. tooled back hearth, . .	/8	1	4	$6\frac{1}{2}$
34	6	,, 2 in. tooled shelves, . . .	1/	1	14	6
8	0	,, 6 in. tooled sink, ...	4/	1	12	0
6	0	Run tooled solid step, 12×6 in., ...	3/	0	18	0
20	0	,, parallel coping, 11×3 in., throated, .	1/7	1	11	8
18	0	,, cutting and pinning, ...	/10	0	15	0
		2 Rounded corners to sink, ...	1/	0	2	0
		1 Rebated pipe-hole, ...	/6	0	0	6
		2 Fan ends to parallel coping, . . .	/4	0	0	8
		28 Ends of sills, pinned, ...	/6	0	14	0
		4 Fan ends to steps, ...	/6	0	2	0
		2 Ends of coping, pinned, ...	/6	0	1	0
		Attend on, cut away for, and make good after all trades, ...		1	0	8
				£53	18	8

CARPENTER.

Sqrs.	ft.	in.		@	£	s.	d.
	18	0	Cube oak in sleepers, templates, &c., .	4/6	4	1	0
	46	3	,, fir in lintels, &c., ...	2/11	6	14	$10\frac{3}{4}$
	115	0	,, fir in wall-plates, ...	3/1	17	14	7
	626	10	,, fir in roof, floors, and partitions, .	3/3	101	17	$2\frac{1}{2}$
			Carry forward,		£130	7	$8\frac{1}{4}$

Sqrs.	ft.	in.		@	£	s.	d.
			Brought forward,		130	7	8¼
	43	1	Superficial centring to trimmers, . . .	/3½	0	12	6½
	151	8	" 1 in. deal gutter and bearers, .	/10	6	6	4½
	105	0	" ¾ in. deal eaves-boards, . .	/4	1	15	0
	10	6	" 1½ in. deal, wrought one side, ploughed, tongued, and beaded cistern bottom, ...	/9	0	7	10½
	26	0	" 1½ in. deal dovetailed rims, .	/10½	1	2	9
1	20	0	" 1 in. deal boarding for lead edges, shot, ...	36/	2	3	2¼
1	20	0	" firrings to flat, ...	10/	0	12	0
	60	0	Run rounded edge, 2 in. deal, . . .	/1½	0	7	6
	140	0	" tilting fillets, ...	/1½	0	17	6
	29	0	" deal springers, ...	/3	0	7	3
	180	0	" deal square angle-staff, . . .	/4	3	0	0
	38	0	" rounded roll for lead, . . .	/4	0	12	8
			12 Rebated drips, ...	/4	0	4	0
			4 Cesspools, ...	1/8	0	6	8
			4 Turning pieces, 6 feet long, . .	1/3	0	5	0
			10 Do. do. 3 ft. 6 in. long, . .	/10	0	8	4
			Labour to fixing six 1¼-in. king-rods, with nuts and screws, ...	3/6	0	3	6
			Attend on, cut away for, and make good after all trades, ...		1	10	0
					£151	9	10

JOINER.

Sqrs.	ft.	in.		@	£	s.	d.
	4	9	Cube fir proper door-case, ...	4/8	1	2	2
8	41	0	Superficial 1¼ in. yellow deal, straight joint floor, side nailed and splayed headings, ...	48/	20	3	8
8	81	0	" 1¼ white deal, do. do., . .	42/	18	10	0

Sashes and Frames.

Sqrs.	ft.	in.		@	£	s.	d.
	113	4	Superficial deal cased frames, oak sills, with solid muntins; 2 in. lamb's-tongue sashes, white lines, iron weights, and brass axle-pulleys,	1/9	9	18	4
	136	0	" deal cased frames, oak sills, 2 in. lamb's-tongue sashes, hung with brass pulleys, lines, and weights,	1/4	9	1	4
	192	4	" deal cased frames, oak sills, 1¾ in. lamb's-tongue sashes, hung with pulleys, lines, and weights, .	1/3	12	0	5
	92	0	" deal cased frames, oak sills, 1½ in. ovolo sashes, hung with pulleys, lines, and weights, . .	1/1	4	19	8
	10	1	" 2 in. deal ovolo fanlight in one square, ...	/9	0	7	6¾
			Carry forward,		£76	3	1¾

Ft.	in.			@	£	s.	d.
			Brought forward,		76	3	1¾
			Boxings and Shutters.				
101	10	Superficial	1 in. deal, wrought, tongued, and beaded linings on splay, . .	/7	2	19	4½
54	0	,,	1¼ in. proper boxing on splay, .	1/2	3	3	0
48	3	,,	1¼ in. deal 1-panel moulded window-back, ...	/11	2	4	2¾
18	4	,,	1 in. deal moulded window-back,	/10	0	15	3¼
14	6	,,	1¼ in. deal moulded elbows, splayed,	/11	0	13	3½
26	0	,,	1¼ in. deal moulded soffit on splay,	1/3	1	12	8
76	0	,,	1 in. deal bead butt back-lining, .	/9	2	17	0
72	0	,,	1½ in. deal 2-panel moulded front shutters on splay, prepared to cut,	1/4	4	16	0
84	0	,,	1¼ in. deal bead butt back-flaps, .	1/1	4	11	0
40	3	,,	1½ in. deal bead butt lifting shutters, hung with lines and weights, .	1/5	2	17	0¼
13	6	,,	1¼ in. deal bead butt and square shutters, ...	1/1	0	14	7½
			Jambs and Doors.				
8	0	Superficial	1¼ in. deal rounded linings, .	/10	0	6	8
160	0	,,	1¼ in. deal rebated and beaded jamb-linings, ...	/9½	6	6	8
36	0	,,	1¼ in. deal rebated double and rounded ditto, . . .	/10	1	10	0
228	5	,,	1 in. deal framed and grooved grounds, ...	/7	6	13	2¾
36	0	,,	2¼ in. deal moulded inside, and bolection-moulded outside door,	2/4	4	4	0
64	0	,,	2 in. deal 6-panel, moulded both sides, folding-doors, . .	1/6	4	16	0
238	0	,,	1½ in. deal 4-panel, moulded both sides, doors, ...	1/3	14	17	6
59	0	,,	1½ in. deal sash-door, with diminished stiles and marginal squares, ...	1/6	4	8	6
20	3	,,	1½ in. deal 4-panel bead butt door,	1/2	1	3	7½
124	0	,,	1½ in. deal 4-panel square door,	/11	5	13	8
20	6	,,	1¼ in. deal, wrought and beaded proper ledged door, . .	1/1	1	2	2½
			Fittings, &c.				
24	0	Superficial	1 in. deal cupboard, top-cross tongued on bearers, . . .	/9	0	18	0
112	0	,,	1 in. deal X-tongued shelves on bearers, ...	/7½	3	10	0
171	0	,,	1¼ in. deal framed and beaded closet front, with 4-panel door in ditto, ...	/11	7	16	9
			Carry forward,		£163	14	2¾

Ft.	in.		@	£	s.	d.
		Brought forward,		163	14	2¾
9	9	Superficial 1 in. deal seat-riser and bearers,	/10	0	8	1½
96	0	„ mouldings to architraves, &c.,	1/	4	16	0
		Skirtings.				
88	11	Superficial 1½ in. deal rebated plinth, tongued at angles,	/11	4	1	6
233	0	„ 1 in. deal torus skirting, tongued at angles,	/10	9	14	2
58	1	„ 1 in. deal square skirting,	/9	2	3	6¾
26	0	Run boxing to shutters, double hung,	1/1	1	8	2
96	0	„ mouldings, 6 inches girt,	/7	2	16	0
480	0	„ ditto, 3½ ditto,	/4½	9	0	0
50	6	„ glued and mitred borders to slabs,	/3	0	12	7½
40	0	„ beaded capping,	/3	0	10	0
3	0	„ rounded nosing,	/3	0	0	9
6	6	„ square skirting to water-closet,	/5	0	2	8½
7	0	„ framed grounds, with beaded pipe-casing, 9 in. wide,	1/	0	7	0
6	0	„ meat rail,	/4	0	2	0
6	0	„ ¾ in. double-beaded pin-rail,	/5	0	2	6
405	0	narrow grounds,	/2	3	7	6
		2 1½-in. ovolo sashes and linings, hung complete, 2 feet × 1 foot 8 in.,	7/6	0	15	0
		8 Beaded elbow-cappings,	/9	0	6	0
		8 Mitres in moulding, 9 in. girt,	/5	0	3	4
		3 Wood drawer-knobs,	/6	0	1	6
		1 Seat-hole, cut and dished,	/9	0	0	9
		1 Cover and brass knob,	1/	0	1	0
		6 Turned pegs to pin-rail,	/4	0	2	0
		1 Dresser, 8 ft. long, 2 ft. wide, with 3 drawers, pot-board and bearers, 3 tiers of shelves, with plate groove cut standards, fascia and moulding,		6	0	0
		1 Deal turned plate-rack, 3 ft. 6 in. × 3 ft.,	24/	1	4	0
		Sundries in Honduras Mahogany.				
13	0	Superficial 1 in. seat, riser and bearers,	2/3	1	9	3
7	0	„ 1 in. clamped flap and beaded frame,	2/6	0	17	6
4	0	Run rounded nosing, tongued to flap and frame,	/6	0	2	0
7	6	„ ¾ in. beaded skirting to ditto,	/9	0	5	7½
24	0	„ 2½ in. moulded hand-rail,	2/9	3	6	0
4	0	„ wreathed ditto,	8/	1	12	0
		1 End of hand-rail pinned,	/6	0	0	6
		4 Hand-rail joints, nuts, and screws,	/9	0	3	0
		2 Tongued and mitred angles to skirting,	/6	0	1	0
		1 Seat-hole, cut and dished,	1/	0	1	0
		1 Beaded handle-hole,	1/6	0	1	6
		Carry forward,		£219	16	7½

Ft.	in.		@	£	s.	d.
		Brought forward,		219	16	$7\frac{1}{2}$
		Staircases.				
18	0	Superficial 1 in. deal landings-on, and including fir-framed bearers, $7 \times 2\frac{1}{4}$ in.,	/9	0	13	6
44	0	" $1\frac{1}{4}$ in. deal treads and risers, with rounded nosings on proper fir carriages, 4×2 in., housed to wall and inner string,	1/	2	4	0
12	0	" $1\frac{1}{4}$ in. deal plain beaded wall-string,	/10	0	10	0
12	0	" $1\frac{1}{4}$ in. deal outer ditto,	/11	0	11	0
336	0	" $1\frac{1}{4}$ in. deal moulded treads, with inch risers on fir, proper carriages, $4 \times 2\frac{1}{2}$ in., housed to wall-string, notched and mitred to string-board, and glued, blocked, and bracketed,	1/2	19	12	0
19	6	" $1\frac{1}{4}$ in. rebated and beaded wall-string,	/11	0	17	$10\frac{1}{2}$
19	6	" $1\frac{1}{4}$ in. framed, sunk-beaded, and staff-beaded inner string,	1/1	1	1	$1\frac{1}{2}$
48	0	" $1\frac{1}{4}$ in. deal moulded spandril-framing,	1/1	2	12	0
156	0	Run deal bar balusters, $1\frac{1}{4}$ in. square, one end framed,	$/1\frac{1}{2}$	0	19	6
3	6	" rounded nosing,	/3	0	0	$10\frac{1}{2}$
12	0	" deal $2\frac{1}{4}$ in. moulded hand-rail,	/9	0	9	0
3	0	" deal $2\frac{1}{2}$ in. newel,	/6	0	1	6
		19 Housings to moulded flyers,	/9	0	14	3
		18 Return mitred and moulded nosings,	/6	0	9	0
		22 Housings to rounded flyers,	/6	0	11	0
		1 Turning to newel,	/1	0	1	0
		1 Proper curtail end to step,	18/	0	18	0
		4 Ramps in beaded wall-string,	1/6	0	6	0
				£252	8	3

IRONMONGERY,

Including Fixing and Screws.

Ft.	in.		@	£	s.	d.
21	0	Run locking bar with plates, &c.,	2/	2	2	0
		$1\frac{1}{2}$ Pair $4\frac{1}{2}$ in. iron butts,	1/	0	1	6
		3 Pair $1\frac{1}{2}$ in. @ 5d.; 4 pair 2 in. @ 5d.; 18 pair $2\frac{1}{2}$ in. @ 6d.,		0	11	11
		18 Pair 3 in. @ 9d.; 16 pair $1\frac{1}{2}$ in. @ 5d. back flaps,		1	0	2
		7 Pair 3 in. brass butts, @ 2s.; 2 pair 2 in. do., @ 1s. 6d.,		0	17	0
		15 Brass spring roller-sash fastenings,	1/	0	15	0
		2 12-in. brass flush-bolts,	2/3	0	4	6
		2 Small ditto, ditto,	/8	0	1	4
		2 Brass knobs,	/4	0	0	8
		Carry forward,		£5	14	1

	@	£	s.	d.
Brought forward,		5	14	1
16 Ebony shutter-knobs,	/4	0	5	4
2 Swing centres, for sashes,	1/	0	2	0
2 Flush lifting rings,	1/	0	2	0
1 Thumb-screw and plates,	/6	0	0	6
1 Knocker @ 5s., 1 bronze knob @ 2s.,		0	7	0
1 Barrel and chain,	2/9	0	2	9
1 9-in. draw-back lock,	10/	0	10	0
2 12-in. barrel-bolts, brass knobs,	1/6	0	3	0
5 7-in. mortise-locks,	12/	3	0	0
10 6-in. ditto, ditto,	8/6	4	5	0
5 6-in. iron rim-locks,	5/	1	5	0
1 Wine-cellar lock,	10/	0	10	0
1 Water-closet door-latch, private bolt,	5/6	0	5	6
1 Bow-latch fastener,	2/6	0	2	6
		£16	14	8

PLASTERER.

Externally, in Blue Lias.

Yds.	ft.	in.			£	s.	d.
304	0	0	Superficial blue lias, jointed,	1/10	27	17	4
117	0	0	,, ditto with rustics,	2/3	13	3	3
	20	0	,, plain face to freize, margins, &c.,	/3½	0	5	10
	15	0	,, raised panels, including dubbing,	/6	0	7	6
	120	0	,, weather top to cornices,	/4	2	0	0
	346	0	,, mouldings,	1/1	18	14	10
	214	0	Run 5-in. reveal and arris,	/4½	4	0	3
	61	0	,, ditto, with rustics,	/8	2	0	8
	110	0	,, moulded coping, 24 in. girt, with 2 arrises and 2 throats,	2/10	15	11	8
	20	0	,, 5 in. margin and arris,	/5	0	8	4
	100	0	,, 3 in. ditto and arris,	/3½	1	9	2
	101	0	,, moulded string, 7 in. wide, including dubbing,	1/	5	1	0
			18 Cast balusters, 18 in. high, fixed,	2/6	2	5	0
			6 Half ditto, ditto,	2/	0	12	0
			2 Modillion trusses, 2 feet deep, with acanthus leaf at foot,	7/6	0	15	0
			4 Mitres, 28 in. girt,	2/	0	8	0
			2 Ditto, 18 in. ditto,	1/7	0	3	2
			16 Ditto, 15 in. ditto,	1/5	1	2	8
			4 Ditto, 7 in. ditto,	/8	0	2	8
			10 Ditto, 6 in. ditto,	/7	0	5	10
			2 Fair ends to coping,	/6	0	1	0
			12 Slopped ends,	/4	0	4	0

Plasterer's Work, Internally.

Yds.	ft.	in.			£	s.	d.
224	1⅓	0	Superficial lath plaster, 2 coats, float, and set,	1/6	16	16	9
181	1½	0	,, lath plaster, 2 coats, set,	1/3	11	6	10½
			Carry forward,		£124	16	9½

Yds.	ft.	in.		@	£	s.	d.
			Brought forward,		124	16	9½
260	0	0	Superficial twice white ceilings,	/2	2	3	4
104	0	0	" twice colour walls,	/4	1	14	8
401	0	0	" render 2 coats, and set,	/7	11	13	11
	551	0	" plaster mouldings,	/9	20	13	3
	116	0	Run enriched soffit, 5 in. girt,	/11	5	6	4
	180	0	" Martin's cement to outer angles,	/5	3	15	0
			12 Mitres to 5 in. enrichment,	1/	0	12	0
			12 Ditto in moulding 20 in. girt,	1/8	1	0	0
			6 Ditto ditto 18 in. girt,	1/6	0	9	0
			40 Ditto ditto 8 in. girt,	/7	1	3	4
			2 Centre flowers, 2 feet diameter,	15/	1	10	0
			Make good round 9 chimney-pieces,	1/	0	9	0
					£175	6	7½

SLATER.

Sqrs.	ft.	in.					
16	19	0	Superficial countess slates on battens, nailed with copper nails,	26/	21	0	11¼
	20	0	" rubbed slate-shelf,	1/7	1	14	10
			1 Slate-cistern to hold 250 gallons, with iron stays and copper bolts, fixed,	90/	4	10	0
			Make good all broken slating, and leave the whole perfect,		0	10	0
					£27	15	9¼

PLUMBER.

Ft.	in.					
		28 Cwt. milled lead, in gutters, &c., and labour,	29/	40	12	0
		1½ Cwt. ditto in cisterns,	30/	2	5	0
17	0	Run soldered angle,	/9	0	12	9

Pipes, including Joints.

30	0	Run ½ in. pipe,	/7	0	17	6
8	0	" ¾ in. ditto,	/9	0	6	0
100	0	" 1 in. ditto,	1/	5	0	0
20	0	" 1½ in. ditto,	1/6	1	10	0
5	0	" 2 in. ditto,	1/8	0	8	4
5	0	" 4 in. soil-pipe,	3/	0	15	0
		1 ½-in. brass ball-cock and ball,	5/6	0	5	6
		1 ¾-in. brass bib-cock,	6/6	0	6	6
		2 1-in. brass ball-cocks with balls and bosses,	14/	1	8	0
		1 Brass union-joint,	8/6	0	8	6
		2 Brass washers and wastes,	3/	0	6	0
		1 Brass grating and bell-trap,	2/	0	2	0
		1 Best water-closet apparatus and queen's-ware pan, complete,	70/	3	10	0
		1 D-trap,	18/	0	18	0
		1 Putty joint,	/6	0	0	6
		1 Basin, cemented down,	1/6	0	1	6
				£59	13	1

Smith.

Ft.	in.		@	£	s.	d.
124	0	Run 4 in. cast-iron rain-water pipe, .	1/3	7	15	0
22	0	,, 5 in. ditto eaves-gutter and brackets,	1/	1	2	0
		6 Rain-water heads, ...	10/	3	0	0
		2 Elbows, ...	5/6	0	11	0
40	0	Run wrought-iron chimney-bar, 3 in. × $\frac{1}{2}$ in.,	1/6	3	3	0
		4 24-in. common stoves, with coverings,	12/6	2	10	0
		3 26-in. register ditto, ...	30/	4	10	0
		1 54-in. range, with oven and boiler, .	70/	3	10	0
		1 Copper, 2 feet diameter, ...	20/	1	0	0
		6 $1\frac{1}{4}$-in. iron king-bolts, with heads, nuts, and screws, ...	10/	3	0	0
		2 Wrought-iron framed window-guards,	25/	2	10	0
		1 Coal-plate and chain, ...	7/6	0	7	6
		10 Wrought-iron bar balusters. . .				
				£32	18	6

Painter.

Yds.	ft.	in.		@	£	s.	d.
299	0	0	Superficial four times in oil, a tint, .	/8	9	19	4
6	0	0	,, three times in oil, finished green,	/7	0	3	6
	88	0	Run moulded plinth, 13 in. high, .	/$2\frac{3}{4}$	1	0	2
	229	0	,, torus skirting, ...	/$1\frac{3}{4}$	1	13	$4\frac{3}{4}$
	57	0	,, square ditto, ...	/$1\frac{1}{2}$	0	7	$1\frac{1}{2}$
	124	0	,, R. W. pipe, ...	/$2\frac{1}{2}$	1	5	10
	22	0	,, eaves-gutter and brackets, . .	/$2\frac{3}{4}$	0	5	$0\frac{1}{2}$
	156	0	,, bar baluster, ...	/1	0	13	0
	6	0	,, meat-rail, ...	/1	0	0	6
	8	0	,, pipe-casing, ...	/$1\frac{1}{2}$	0	1	0
	12	0	,, hand-rail, ...	/$1\frac{1}{4}$	0	1	3
			12 Frames @ 1s. 4d.; 3 large ditto @ 2s. 6d.,		1	3	6
			2 Casements and linings, ...	1/	0	2	0
			13 Dozen squares @ 1s. 4d.; 1 dozen large ditto @ 2s. 6d., ...		0	19	10
			6 R. W. heads @ 6d.; 2 elbows @ 6d.,		0	4	0
			1 Dresser, with drawers, pot-board, and shelves, ...	10/	0	10	0
11	0	0	Grain wainscot and seconds varnish, .	2/3	1	4	9
	7	6	Run narrow mahogany skirting, French polished, ...	/4	0	2	6
	24	0	,, moulded hand-rail, ...	/6	0	12	0
					£20	8	$8\frac{3}{4}$

Glazier.

171	6	Superficial seconds Newcastle crown-glass, glazed into sashes, under 2 ft. 6 in., in one square, ...	/10	7	2	11
174	0	Superficial ditto, under 2 ft. in one square,	/9	6	10	6
		12 Sqres. of polished sheet, 2 ft. 9 in. × 1 ft.,	2/	1	4	0
		16 Ditto, ditto, 1 foot × 1 foot 10 in.,	1/6	1	4	0
		Twice cleaning 13 dozen squares, .	/6	0	6	6
		Ditto 12 large ditto, .	/6	0	6	0

SUMMARY.

Excavator,	£55	3	0
Bricklayer,	334	2	8
Mason,	53	18	8
Carpenter,	151	9	10
Joiner,	252	8	3
Ironmonger,	16	14	8
Plasterer,	175	6	7½
Slater,	27	15	9¼
Plumber,	59	13	1
Smith,	32	18	6
Painter,	20	8	8¾
Glazier,	16	13	11
	£1196	13	8½
Surveyor's charge, 2 per cent,	24	2	0¾
Total,	£1220	15	9¼

As useful addenda to this department we here append the plans of four methods of arranging School-rooms, adapted for rural and suburban districts. The whole are arranged according to the following rules furnished by the "Committee of Council on Education," on the principle of "parallel groups of benches or desks":—

1. Where the width of a school-room is 18 feet, 8 or 9 square feet for each child should be the amount of floor surface allowed, increasing this in proportion to increase of width.

2. Where the children vary from seven to thirteen years of age, they should be divided into not less than four classes.

3. Parallel benches with desks should be provided for all the scholars in actual attendance.

4. In order that the teacher should be able to see the slates of the last row of pupils, and also to be heard by all without raising his voice to a high pitch, the groups should not contain more than three rows of desks, the number of children in each row, as a general rule, being confined to eight, or twenty-four pupils in each group, allowing 18 inches of such room for each. This is found to be a proper length for a seat.

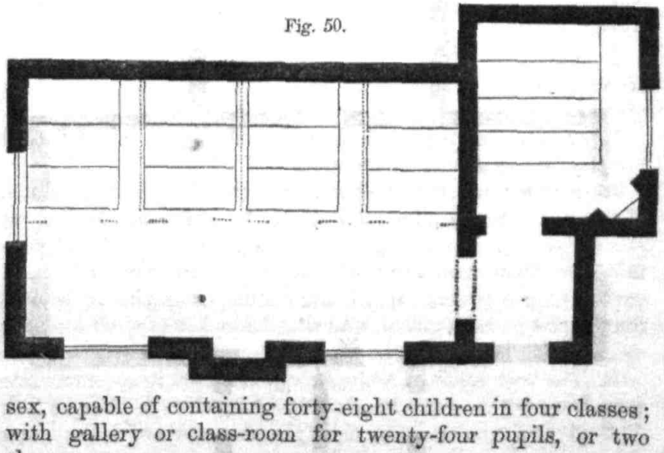
5. The best width of a class-room intended to accommodate from forty-eight to one hundred and forty-four is 17 or 18 feet. This gives ample space to place the three rows of desks along the back wall, with space in front of each for the class stand-

ing upon when required, or for the teacher to place his "diagram easel." This being all the accommodation required, any increase in the width only gives increase of cost without increase of accommodation.

6. The number of groups should be limited to six, giving accommodation to one hundred and forty-four pupils: where this number is exceeded, the additional accommodation required, should be obtained by the erection of another school-room; or by doubling the width, and placing the groups of desks on each side of the room. This latter plan is not to be recommended however, the necessary isolation and general superintendence before noted not being attainable: the classes see into each other's division, and the teachers, being too near each other, interfere with the operations going on at each class. The plan of arrangement shown in fig. 53, where one part or wing is at right angles to the other, is infinitely superior to that in which the width is doubled. For the details of construction, lighting, heating, ventilating, and arrangement of desks and fittings, we beg to refer the reader to our work on *The Construction and Arrangement of Schools and School-Houses*, (3s.: Blackwood). The following are the plans above referred to:—

Fig. 50 shows the ground-plan of a school-room for one

Fig. 50.



sex, capable of containing forty-eight children in four classes; with gallery or class-room for twenty-four pupils, or two classes.

Fig. 51.

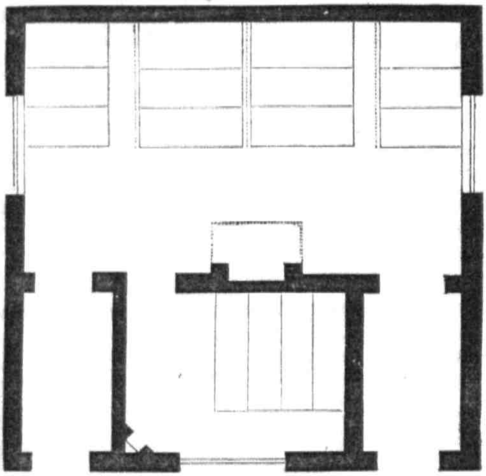


Fig. 52.

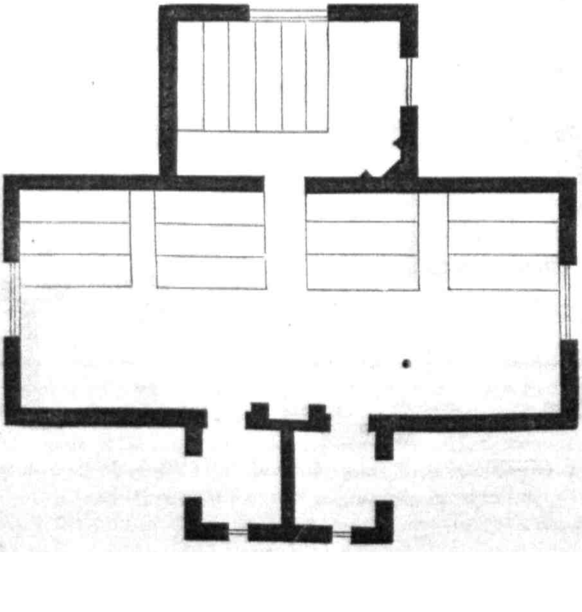
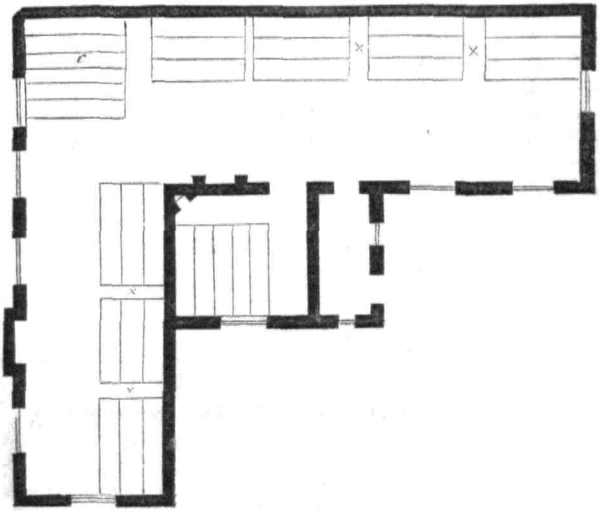


Fig. 51 is the plan of a school for twenty-four boys, with an equal number of girls; a separate entrance-lobby being provided for each class. A gallery is provided.

Fig. 52 is the plan of a school for seventy-two (boys and girls) in four classes, with a gallery for two of the classes.

Fig. 53 is the plan already referred to for a school to contain more than one hundred and forty-four children (in this case one hundred and sixty-eight), one part being at right angles to the other.

Fig. 53.



SECTION THIRD.

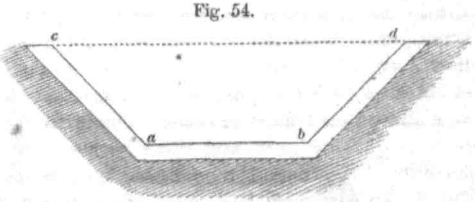
FIREPLACES, STOVES, AND COOKING-OVENS.

HEAT, as obtained by the combustion of coals in a grate, consists of two kinds—"radiant" and "combined." As we have remarked elsewhere, "radiant heat is diffused through the air at an immense velocity, without materially raising its temperature, but immediately warming solid bodies exposed to its influence, its effect being increased in proportion to the number of points which a body presents; hence it is more rapid in rough surfaces than in smooth ones. The sun, fire, candles, gas, all give out radiant heat. In an apartment warmed by an open fire, the heat thrown out raises the temperature of surrounding bodies, which in turn give out the acquired heat slowly. High temperature is required in bodies ere they can throw off much radiant heat; the redder the fire in an open fireplace, the warmer is the radiant heat: it follows, then, that bodies at a low temperature—*i. e.* below 212°—afford very little heat from radiation. Radiant heat is unequal in its effects—some part of the body may be overwarmed by it, whilst others may be cold; moreover, it can only be used on a small scale. If large fires be kept up to raise the temperature of the room, the heat near them is too great, diminishing as the square of the distance to positive inefficacy. The attendant disadvantages of a number of fires are too obvious to be more particularly indicated." The combined heat is that which passes off from the fire in the shape of heated air and smoke, and also that "conducted" or led off by the surrounding materials, of which the grate or fireplace is composed. The radiant heat of a fireplace is that chiefly available for warming the room; and it bears a small proportion—estimated at one-third—to the combined, which in nine cases out of ten is altogether lost. Radiant heat being chiefly derivable

from red-hot surfaces, the greater the amount of red clear-burning fuel presented to the room, the more heat will be obtained. Metallic bodies are quick conductors of heat, and serve, when much used about grates, to rob the fire of a certain amount of available and otherwise useful heat; hence the less metal used the better, and the rule that brick and other non-conducting material should, in all cases where adaptable, be alone used. Rays of heat in a fireplace are reflected from the surrounding surfaces, in accordance with well-known laws; scientific men have studied these, and have deduced simple rules, by following which, the rays of heat from a fire, instead of being reflected in directions—useless, so far as the heating of the room is concerned—are sent, in the proper course, to fulfil their destined purpose.

It is foreign to the scope of the present treatise to enter into the consideration of these rules, and the principles on which they are founded; suffice it to say, that theory demonstrates that the worst form which the surrounding surfaces of a fireplace can have, is that at which the back is at right angles to the sides—that is, the plan of the fireplace being an oblong or square—the best form being the "parabolic." As this, however, will be difficult to describe, we give in fig. 54 a diagram illustrative of the form recommended by Count Rumford, the sides *a c b d* being at an angle of 135′ to the back. There are two kinds of fireplaces in use—one for cooking as well as warming; the other chiefly for warming.

Fig. 54.



Let us note their distinguishing features. In the first, two kinds of heating-surfaces are required: first, "horizontal," or that presented by what is called the "top of the fire," and is used for boiling and other kindred purposes; the second is "vertical," or that presented by the depth of the burning fuel, or what is known as the "front or bars of the fire," and is available for roasting, toasting, &c. In the sitting-room grate it is obvious that only one kind of heating-surface is

wholly available—that is, the "vertical," or front; the horizontal chiefly passes its heat up the chimney—especially if the grate is placed far from the floor, unless, indeed, the fuel is made to slope from the front bar towards the back, when a species of mongrel surface is produced, three-fourths of the heat of which is lost. Let us trace the matter still further: the lesson we derive from this will amply repay the trouble of acquiring it. In the "box-grate," as we may call it, a diagram illustrative of which we give in fig. 55, we have the two kinds of heating-surfaces requisite in a cooking grate amply developed—horizontal, as *a b*, and vertical, as *a c*; but at what cost are these obtained?—Why, at the expenditure of a mass of fuel contained within the space of *d*, nine-tenths of which are allowed to burn in absolute waste. Apply this to a sitting-room—you have good, efficient, room-warming heat from the vertical surface *a c*, but nearly all from *a b* passes up the chimney, as indicated by the arrows. Slope your fuel as in the dotted lines *a* to *e*, you not only literally but metaphorically add "fuel to the fire," for you increase the surface for waste, and obtain little corresponding advantage. Note, then, how a knowledge of the true source of heat from a common fire enables us to obviate unnecessary waste. A glance at fig. 56 will show how this is effected: ample vertical with horizontal space, and the internal ineffective portion reduced to a minimum; equal heating-surfaces with half the fuel—all this by merely sloping the back of the grate. For a large kitchen-grate, the proportions as follows were found to be efficient: the breadth *a b*, fig. 57, from side to side, being 14 inches, the depth from top to bottom bars, inclusive, 10 inches; the width at fig. 58, from inside of top-bar to back of grate, 6 inches; that at bottom, as of 4 inches. For a grate for heating a room, the lower we place the fire to the floor the better; and the more heating effect will be obtained where

Fig. 55.

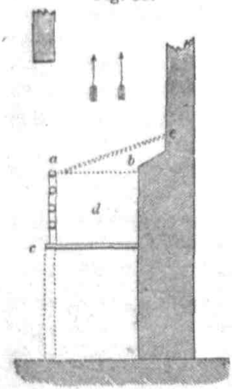
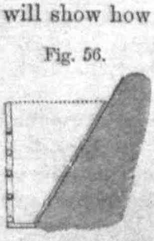


Fig. 56.



the grate is used for warming (not cooking) alone. By placing the grate near the floor, a double effect is obtained: the floor, in the first instance, is heated, thus warming the currents of air which usually flow along and over it from all parts of the room to the fireplace, and which ascend upwards to the room, communicating heat; but the rays of heat from the horizontal surface, or "top of the fire," are thrown into the room to a large extent, instead of flying up the chimney, as would be the case were the grate placed near its opening. Instead of placing the grate far back within the jambs, thus throwing a large portion of the heat on their middle surfaces, it should be placed so that the front bars will be flush with the outside of the jambs. The material best fitted to form the back and sides of fireplaces is brick—if whitened on its surface, the better. Plans have been proposed by which the heat of a fire, imparted to the surrounding materials, is made available for the purpose of heating a quantity of cold air admitted to a recess made behind the grate—this air being afterwards admitted to the room. To assist the reader in designing a plan by which to carry out this useful contrivance, we offer the following: The fireplace is at *b b*, fig. 59; at the back of this a space is made 9 inches wide, and as high as the grate, and of corresponding breadth with the fireplace. In the centre of this a partition of plate iron is placed, reaching to within 4 inches of the top of the chamber, thus dividing the heating-chamber into two partitions of equal dimensions; the orifice of the cold-air pipe *a a*, leading from the external atmosphere,

Fig. 57.

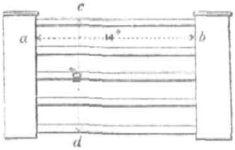


Fig. 58.

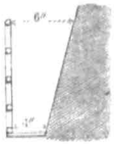
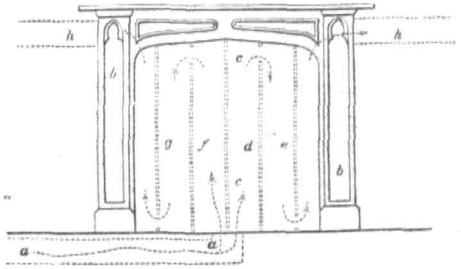
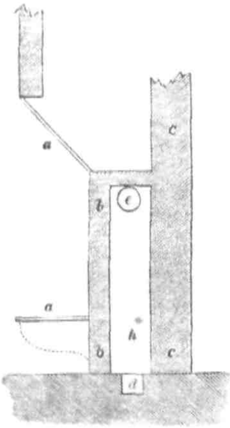


Fig. 59.



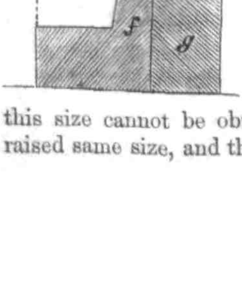
is placed beneath the central partition c c, so that the air passes equally up into the two divisions. Each division is provided with two partitions *d e*, *f g*, making in each, three compartments; at the top of the last of these the pipes *h h*, leading to the wall on each side of the fireplace, convey the warmed air to the apartment. Fig. 60 is a vertical section, showing the arrangement in another point of view: *a a* is the grate, *b b* the brick partition at the back of it; *c c* the wall, *h* the heating-chamber, *d* the cold-air pipe, and *e* that leading to the apartment. The advantages derivable from this plan of economically heating cold air need not be enlarged upon, being obvious on consideration.

Fig. 60.



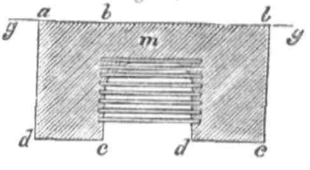
We now proceed to give illustrations, drawn to a scale of ½ inch to the foot, of simple methods of constructing cottage fireplaces: the first of these requires no materials, only brick and mortar, and a few lengths of round rod-iron, some ½ inch or ¾ inch diameter, and 18 inches long. If bricks properly burnt cannot be obtained, unburnt ones may be used—the thinner these are the better: if of good "fire-clay," the stove or grate will last long enough until the settler has better materials at his command. Let fig. 61 represent a vertical section of fireplace: *g g* the outside wall of house. Build two projecting jambs, *a b c d*, fig. 62, 15 inches from wall, and 9 inches broad on face *c d*; make these 8 inches high. These projections should be built on a flat stone previously placed on the floor, to form the hearth, at the position of fireplace: the dimensions of this should be 3 feet by 2 feet. If a stone of this size cannot be obtained, a platform of brick should be raised same size, and the thickness of an ordinary brick. The

Fig. 61.



distance between inside of projection *c d* is to be 12 inches: the back of the projection is to be made circular, as in fig. 62. When the projections are raised to the proper height, place the lengths of rod iron, as in fig. 62. The first length is to be placed $2\frac{1}{2}$ inches from the outside face of projections *c d*. The depth to which the bars should extend is 8 inches; this will give the thickness of material at the back $4\frac{1}{2}$ inches.

Fig. 62.



After the bars are placed as in fig. 62, proceed to build up the projections, taking care to place from time to time the iron rods *a a*, figs. 61, 63, at proper distances, so as to form the front bars of the grate; the depth of place thus made for the fuel should be 6 inches. Continue to build up the projections, rounding the back as in fig. 62, and sloping it as *f m*, fig. 61, until it is 26 or 27 inches high, measuring from top side of hearthstone: across the top of projections place a chimney-bearer of wood—if of iron so much the better—*e e*, 3 inches thick by 6 or 8 inches broad; the outside of this should be flush or level with the outside of projections—that is, 15 inches from inside line of wall. Proceed, after placing this, to build up the jambs, and contiue them through the roof some 2 feet above the timbers: it must be remembered that above the chimney-bearer *e e* the building is continued at *n n*, figs 61, 63—this forms the front of flue. If the bearer is 5 inches broad, and the thickness of wall above it equal to this, and the back *f* sloped from $4\frac{1}{2}$ inches to 2, the size of chimney-flue in the inside will be 12 inches by 9. This grate is constructed in the simplest manner, but will give satisfaction as warm and economical. To provide jambs on which to rest pots, &c., bricks may be built in at each side: this will reduce the size of fireplace, but not to a hurtful extent; or the same end may be obtained without altering the size of fireplace, by making the jambs *c d* wider, so as to admit of a recess being made,

Fig. 63.

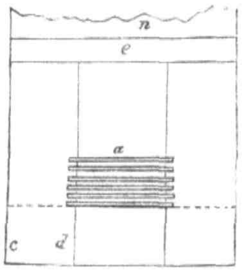
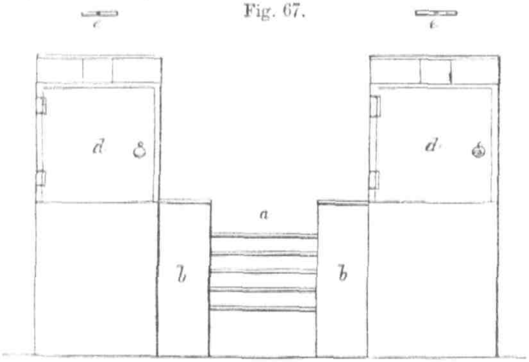


fig. 67 we give the front elevation of a cooking-range, with fireplace, two ovens, and hot-water boiler—the plan of which

Fig. 67.



has been suggested to us by a clever mechanic of some experience in these matters: *a* is the fireplace, *b b* the jambs, the upper surface of which serves as hot plates; *d d* the ovens; *e e* the dampers, to regulate the admission of flame and heated air beneath the oven, as in fig. 65. In fig. 68 the plan is given: the back of the grate *b b* is built up of brick, with a sloping back, as in

Fig. 68.

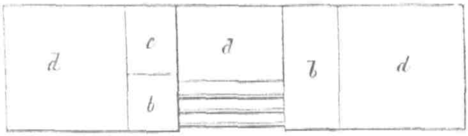
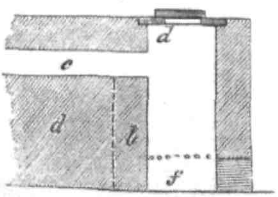


fig. 58: the dotted line shows the amount of slope; *c* is the boiler, *d d* the oven tops.

We shall next notice a few methods of constructing stoves. An exceedingly simple-acting stove for a cabin is shown in fig. 69, which is built of bricks, burnt or unburnt, so as to be 8 or 9 inches square in the inside: when the course, 6 inches from the hearthstone, is reached, the fire-bars *f* should be inserted, and the building continued. A space should be cut out in front through which to withdraw

Fig. 69.



the ashes from below the fire-bars, and to allow the air to reach the fuel. As the simplest arrangement, we give a cover to the top of stove, instead of a door at the side, by removing which the stove may be replenished with fuel, or stew-pans placed on the top to be heated. This cover may be of stone, having its under surface as flat as possible. If this stove is constructed with a flue, *c*, properly—that is, air-tight—attached to the vertical or ordinary chimney-flue, there need be no apprehension of the products of combustion entering the apartment through the cover. The scale to which this example is drawn is 1½ inch to the foot. In fig. 70 we give the plan of top of this stove: *d* the stove, *c* the flue. We present in fig. 71 a section of a simple circular iron stove for heating and cooking—the latter necessarily on a small scale, which we have found to answer admirably as an economical contrivance. A movable cover *a* is provided at the top, on which a pot may be placed, or one of the quick-boiling pans hereafter described (see IRONMONGERY) inserted. The fuel is supplied by the door *b*; *c* is the flue; the whole is supported on legs *d*. To prevent the waste of the iron, an interior coating of fire-clay, as *e e*, may be given to it. As affording some hints which may be useful to the emigrant, we here give illustrations of an easily constructed "cooking-stove," with "baking-oven," and "hot-plate" attached. The drawings, to a scale of ½ inch to the foot, are considered so elucidatory of the construction, that a short description will suffice: *a*, fig. 72, is the stove, 9 inches square; *b* the ash-pit, 3½ inches deep; *d d* a

Fig. 70.

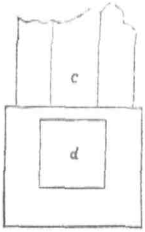


Fig. 71.

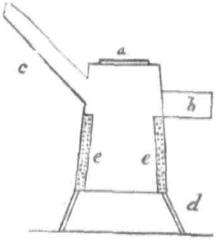


Fig. 72.

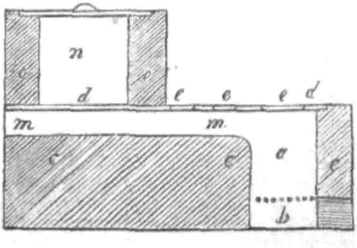
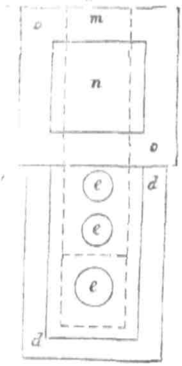
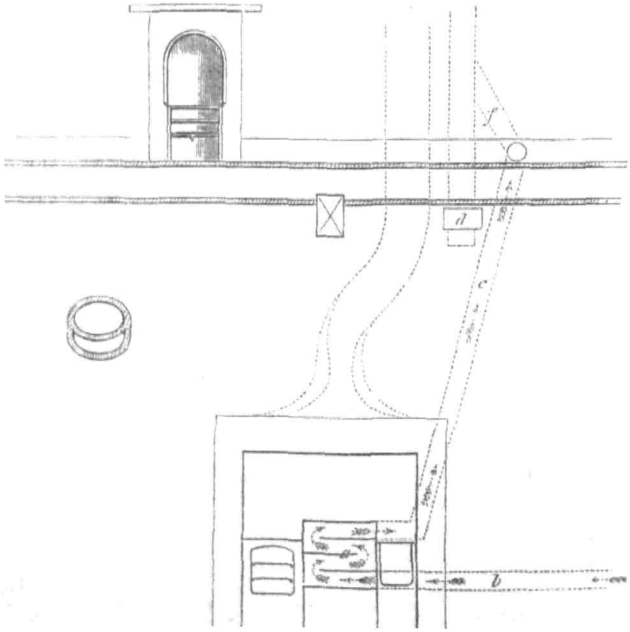


Fig. 73.



cast-iron plate, ½ inch or ¾ inch thick, laid on the brickwork, as in fig. 73, having holes cut in it, as at *e e*, to admit of pans being placed, and covered when not in use by small covers; a flue *m m* is carried along the whole length of stove, and joins the ordinary chimney-flue: the size of this flue is 9 inches by 3; the oven *n* is formed by the sides *o o*, built on the hot-plate *d*. This will be found an effective and economical cooking and baking oven. In fig. 73, the dotted line shows the line of wall against which the stove is erected. Fig. 74 illustrates an arrangement of fireplace for heating upper rooms, as recommended by the Scottish Association for Improving the

Fig. 74.



Condition of Labourers' Cottages. "The hot-air chamber *a* is formed of cast iron, of the same width as the fire, and extending from the bottom of the grate to a few inches over the top of it. The cold air is brought in by the flue *b*, formed in the thickness of the wall, and after circulating through the cells into which the chamber is divided, and being thereby warmed, it is conveyed to the floor above by the flue *c*, and thrown into the room at an opening in the skirting, fitted with a valve: *d* is a ventilator in connection with a ventilating flue, shown by the dotted lines above: it is formed as close as possible to the kitchen flue, the heat of which, being by this means communicated to the ventilating flue, produces an upward current, and thus promotes ventilation. By connecting the hot-air flue with the ventilating flue, as shown at *f*, the hot air, when not required, as in summer, may be allowed to escape, and in this way it will also assist ventilation.

"When vent linings are used, the ventilating and smoke flues may be formed in one piece, as shown in fig. 74, the large opening being the smoke flue, and the small one the ventilating flue. In those parts of the country where fireclay is expensive from the long carriage, vent-linings of well-burnt clay may be used: the first three or four feet should be of fire-clay. With a view to prevent smoke, a small flue is formed of two-inch chain-tiles, built into the wall, as at *e*."

Fig. 75.

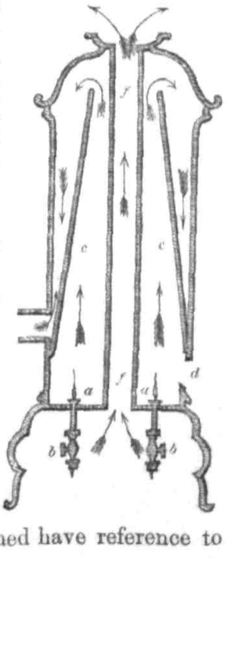


Fig. 75 is a section of Rickett's Gas-Stove: the products of combustion are led off by the lower horizontal pipe, while the pure heated air passes up the vertical one in the centre of the stove. Fig. 76 shows plans of Pierce's Fire-Lamp Grates. Fig. 77 is a sketch of the American Cooking-Stove—admirably efficient for all domestic purposes, and economical in use.

In referring to the preceding remarks in this Section, the reader will observe that many of the plans therein explained have reference to

constructions of an exceedingly simple character; as, for instance, those in figs. 61 to 73. These are, however, designed for the Emigrant Settler, for use in situations where a wide choice of material is not available. In many cases it will best serve the emigrant to take out with him a good cooking-stove; that illustrated in fig. 77 will be found in every way satisfactory. It is, indeed, well adapted for cottages in this country.

Fig. 76.

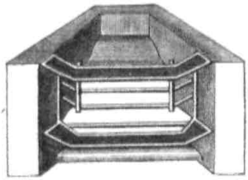
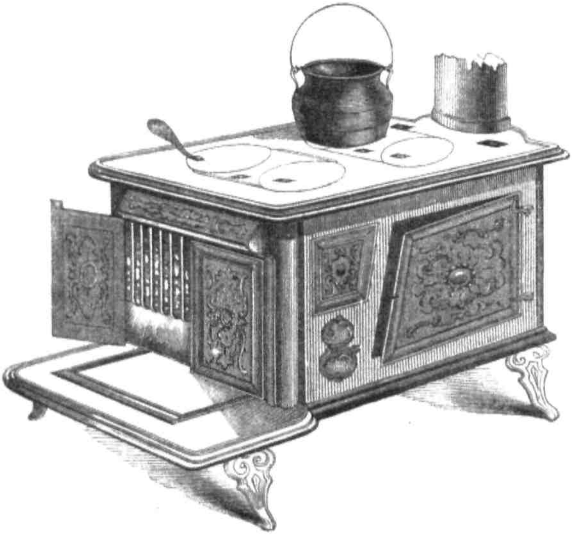


Fig. 77.

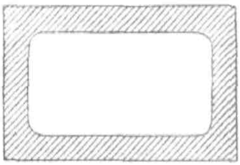


SECTION FOURTH.

CHIMNEYS.

In order to lessen the friction of the ascending smoke, it is *recommended to make the flues circular: this may be done* by using a wooden or tin mould, building round it, and withdrawing it as the operation goes on. As this may be difficult to execute, the corners of the ordinary oblong flue may be *rounded off as in fig 78. As to the carrying up of chimney-*flues, it is to be considered as a rule that—other things being equal—the straighter it ascends, and the fewer the curves and bends in it, the better. The natural course of heated air being upwards, it is obviously the most reasonable plan to make the passage for its exit as vertical as possible; and in this view of the matter, all deviations from the vertical are to be considered as militating against the speedy removal of the products of combustion. In some cases, however, a deviation from this rule is not only allowable, but necessary—as where a house is built in a range with others, or where the flues are numerous in a single house, the direction of some of them must necessarily be changed, to avoid those from other apartments. In all cases, however, where curves are imperatively required, they should be made easy, and of as great a radius as possible—carefully avoiding all right-angled or oblique bends, also roughness or projections in their interior. The hotter the products of combustion in the chimney, the quicker will be their ascent: "for as the smoke is forced up the chimney merely by the rarefaction of the air in consequence of the heat, it is evident that the more the air is

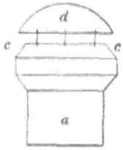
Fig. 78.



heated, with the greater force will it ascend, because the difference between the weight of the external and internal air will be greater; and as the air will be more heated the nearer it is made to pass over the fire in its entrance into the vent, *it is evident that the sooner the wideness of the fireplace is* contracted into the tubular form of the vent, and the lower down or the closer to the fire that contraction takes place, the air in entering it will be made to pass the nearer to the fire, and so, *being more heated and rarefied, will ascend and carry* the smoke along with it with the greater velocity." To attain this desideratum, then, it is necessary not to have the height from the hearth to the under side of the mantel-tree too great. A proportion which has been strongly recommended is, that the height should be one-third of the whole height of the room from the floor-line to the ceiling. In building chimneys, it ought to be an *essential requisite* in construction that no timber be allowed to be near them. Upon the absurdity—often, by the way, practised—of passing beams through them, we hope there is no need further to dilate. Circular earthenware tubes, when used as flues, possess this advantage, that *no wood can* be passed through them; and luckily they are made thick enough to prevent the communication of heat of a dangerous temperature to surrounding materials, even should these be of wood. All chimney-flues should be carried up to the same height above the roof: if not so, the tall ones would overpower the short. Every flue should be independent—that is, it should not communicate with another before issuing to the external air. Such communication, too general in its adoption, is a fruitful source of smoky chimneys. Each grate or fireplace should have a supply of air independent of that which may be obtained from casual means, as through the chinks of doors and windows. This *independent* supply is a matter of the greatest importance: without this being attended to, the chimney, however well constructed, will in all probability smoke; and most certainly this will be the case if the doors and windows happen to fit tightly. Again, by adopting this precaution of giving each fireplace an independent supply, all cross currents and unpleasant draughts are avoided, (see fig. 74.) The higher the chimney the better the draught. The projection above ridge of roof should not be less than two

feet. Single pots, or chimney-tops, are better than clusters—in the latter case, a flat surface, of considerable extent at the top, is formed, across which the wind blows in stormy weather with such force as to press the smoke down the orifices of chimneys. If the top edges of pots are made angular, something like the edge *c* in fig. 79, the wind will be deflected upwards in its passage over the pot, assisting rather than retarding the upward ascent of the smoke in the chimney. If a low cottage is built at the foot of a steep or overhanging hill, in certain winds the chimneys will be almost certain to smoke. To prevent the blow down, a wind-guard should be made: a simple one is shown in fig. 79. The part to pass over the chimney-pot is at *a*; a cover *d* prevents rain from entering the chimney. The angular part deflects the wind passing over it in an upward direction. The cap *d* also serves to prevent perpendicular down-gusts of wind from entering the chimney. A few notes on the important subject of VENTILATION may be of use.

Fig. 79.



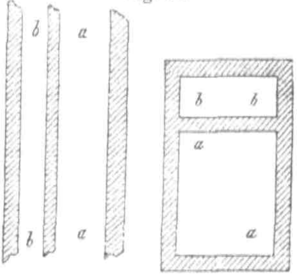
SECTION FIFTH.

VENTILATION.

The most efficient method of supplying fresh air to an apartment, is by means of special channels led from the open air to a chamber behind the fireplace, ultimately leading to the apartment by provisions made in the wall or skirting-board in one or both sides of the fireplace, (see fig. 74). This method is one easily carried out in new constructions, and renders the supply of air easily controlled: one great advantage, moreover, it possesses is, that the air is warmed in winter time. The fresh air may also be admitted to spaces behind the skirting-board, through which it finds access by porous cloth or perforated zinc. Where the lobbies, &c., are well supplied with pure air—which may be warmed by a good stove on a healthy principle, or by hot-water pipes in the hall—the lower panels in the door may be perforated, or composed of perforated zinc or fine wire-gauze—spring-roller silk curtains being provided, either outside or in, by which any portion of the perforated surface may be covered, and the amount of air controlled. Where this plan of admitting air to any apartment is adopted, in conjunction with means for withdrawing the deteriorated air, satisfactory results will follow. In one instance this method was carried out in every apartment with marked success. Having then provided means—which will necessarily depend much upon local and structural circumstances—for the admission of pure air to the interior of apartments, the method of withdrawing it as fast as it becomes deteriorated is next to be considered. The most simple plan, and that easiest to be carried out, is to take advantage of the chimney-flue. The most obvious way of doing this is to make an aperture in the chimney-breast near the ceiling, communicating at once with the interior of the flue; to prevent the smoke from being passed through this into the

apartment, a valve, such as Arnott's Balance Valve, must be used. As this and similar contrivances are, however, liable to get out of order, special ventilating-flues are recommended to be adopted: for methods and forms of these we beg here to refer our readers to one or two illustrations appended, showing the advantages which ordinary chimneys possess as ventilating adjuncts. The heat of the chimney is communicated to the air in the flue near it; and if the air in the room is admitted to this smaller flue, the upward current created will carry off the vitiated air from the apartment—that is, if the communications required are made in a proper place and way. Thus in fig. 80, if *a a* is a chimney-flue, and *b b* a smaller one alongside of it, divided by a partition of brick or stone, the heat of the smoke in the chimney *a a* will be communicated through the partition to the air in *b b*, and an upward current therein will be produced.

Fig. 80.



Suppose *a a*, fig. 81, to be the cornice at the ceiling of a room, *b b* the chimney-breast, the dotted lines representing the course of the chimney-flue and that of the ventilator, the latter beginning somewhere about *d*, a short distance beneath the cornice *a a*—now, if an aperture is made at *e*, communicating with the interior of the ventilating-flue, the upward current therein will withdraw the vitiated air from the room through the aperture *e*.

Fig. 81.

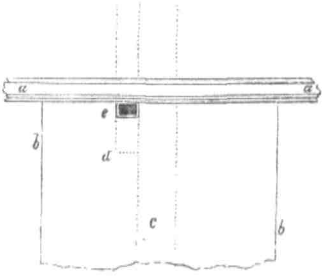


Fig. 82 is a sketch of the combined smoke and ventilating flue manufactured by H. Doulton & Co. of London. *a* is the smoke flue, *b* the ventilating flue; the air from the room to be ventilated passing into it through the aperture *c*.

Fig. 83 illustrates Looker's Patent Ventilators: "The

object of this invention is to meet a requirement daily becoming more felt—namely, a simple, cheap, but effect-

Fig. 82.

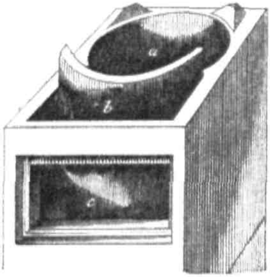
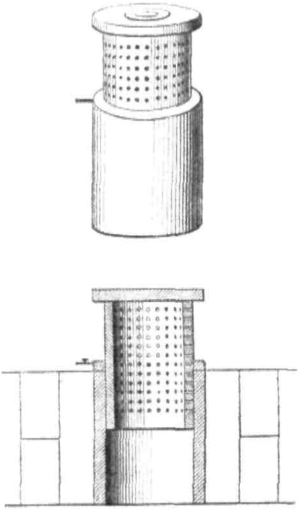


Fig. 83.



ual method of admitting pure air into any kind of building, or in any situation, without a perceptible draught.

"It consists of a tubular piece of pottery, of any size or shape, fixed into the wall of a building, in which, on the inside, another piece with a closed end is made to slide, the latter being perforated around with small holes.

"When the sliding piece is drawn out, fresh air is admitted, or impure air finds egress, without the slightest draught being felt, the closed end preventing a direct current of air from entering the apartment. At the same time, the ventilator may be regulated with perfect ease to any point. A small peg is fixed in the outside tube which works in a slit in the inner one, and which prevents the latter from being drawn out too far.

"The ventilators are made circular, square, or any other shape, and if preferred, with the perforations only on the upper part, or the top of the sliding piece may be entirely open.

"The fixed tube is made in different lengths to suit any thickness of wall or partition, and where the plain aperture on the outside is objectionable, a perforated end is made to fix in the outside of the wall."

Fig. 84 is section of a "louvre-boarded," and fig. 85 of a "turn-cap" ventilator. for the withdrawal of foul air from

large apartments, as schools, cow-houses, &c.; and fig. 86 a "ratchet valve" for admitting pure air.

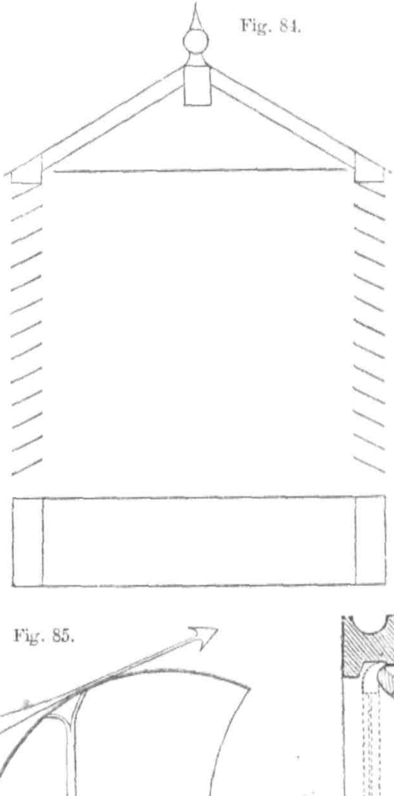
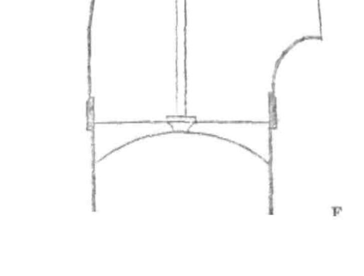


Fig. 84.

Fig. 85.



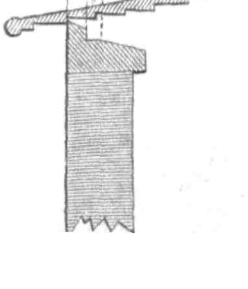


Fig. 86.

SECTION SIXTH.

WATER-CLOSETS.

WHERE at all available, the privy so called should be a *water-closet*—that is, water should be the medium of carrying off the matter as fast as possible, and the terminus for all deposits should be the liquid-manure tank; moreover, that the gases evolved should be strictly prevented from having access to the external air, or to any part of the house if the closet should be situated therein. Taking this to be the standard of perfection, it is to be understood that all deviation from it will result in positive loss or inconvenience, proportionate to the amount of such deviation. It is, we hope, here utterly unnecessary to dilate on the advantages to be derived from liquid manure from dwelling-houses, for horticultural or agricultural purposes; the fact of its value is, or ought to be, patent to all. A method, then, of saving the household exuviæ, and of speedily carrying it off to the manure-tank, is of considerable importance; and the easiest way to insure this is by the use of the important vehicle water. In fig. 87 we give a sketch of a "soil-pan" with water-trap, the pipe of which leads at once to the liquid-manure tank. The defect in this form is, that the water does not come sufficiently high up the pipe from the trap to meet the earthenware basin; therefore, and where the water is otherwise inadequately supplied, a coating of soil is left in the pipe.

Fig. 87.

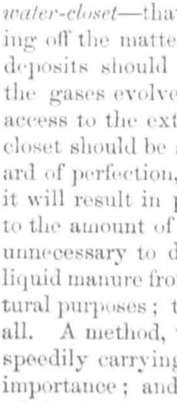


Fig. 88 represents a form of water-closet, pan and trap formed in one piece wholly of earthenware, so as to require no wood-work for its support. The top is spread out about 4 or 5 inches, so as to form a self-sustaining seat. The entrance of the pipe for carrying off the effluvia to a ventilating tube or

chimney is shown at *a*. In cases where these forms are not obtainable, a simple arrangement may be effected at a trifling cost. A box *d d*, fig. 89, may be made of any dimensions, with holes, *c c*, in the ends near the top; a tapering box, *a a*, should pass through an aperture in the top of the box *d d*, and be firmly fastened; the upper end of the tapering box *a a* forms the seat of the closet, and may be covered with a flap if required. An inspection of the drawing will show how the foul air from the cesspool is prevented from ascending the box *a a*, which is the only communication afforded with the cesspool. The liquid and exuviæ passing from the box *a a* will pass from the box *d d* by the aperture *c c* into the cesspool, from whence they may be removed, when necessary, by obvious means. By the adoption of a well-trapped soil-pan the air of the cesspool will be closely confined, and the value of the manure will therefore remain unimpaired, the ammoniacal gases being retained and absorbed. In all cases a pipe should be led from the rain-water tank to the top of the soil-pan beneath the flap cover. A stop-cock should be fastened on this pipe somewhere within reach, which, being opened when necessary, will allow the water to flush the soil-pan and trap. In cases where the water-closet is near or within the house, a portion of the refuse-water from the kitchen may, from time to time, be sent down the soil-pan of the closet with advantage. As this practice—which is not to be

Fig. 88.

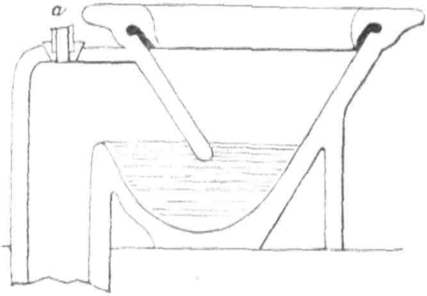
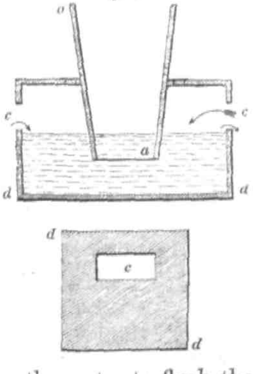
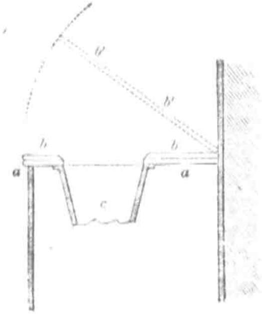


Fig. 89.



recommended before the special and legitimate means of flushing the soil-pan—will, if carelessly done, sometimes wet the flap-seat, the following contrivance (recommended, if we mistake not, by the late Mr Loudon, to a Committee of the House of Commons) may be adopted: A seat, *a a*, fig. 90, with circular aperture, is provided and permanently fixed. A similar one, *b b*, is to be hinged, so as to move up, and be placed against the wall. This is the seat to be used. When not in use, it is opened and placed against the wall; so that if any water be passed down the pan *c*, and wets the permanent seat *a a*, the movable flap *b b* can be brought down and placed above *a a*. The dotted lines *b′ b′* show the movable flap in the act of being opened.

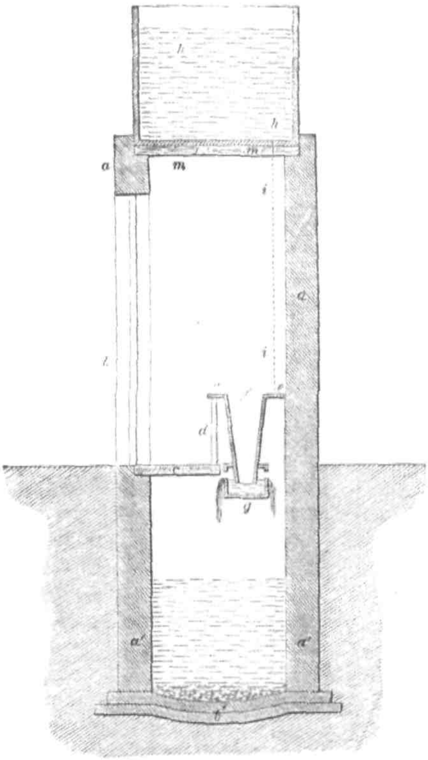
Fig. 90.



In fig. 91 we give an illustration explanatory of an arrangement in which the rain-water cistern, water-closet, and liquid-manure tank are combined in one. This possesses many advantages. The walls *a a* are carried down a sufficient depth, as at *a′ a′*, to form the liquid-manure tank. An arched bottom, *b*, may be provided if the tank is of large dimensions. In fig. 92 the plan is given. A stone flag, *c c*, is thrown across at the level of the ground, which forms the covering of the tank and the floor of the closet. This flag reaches only a certain distance across the opening of the tank, leaving a space, *o o*, through which the contents of the tank may be removed. In ordinary times this aperture is tightly covered with a board, in the centre of which is the aperture and cover *e e*, to which is attached the soil-pan *f*, and trap *g*. The front *d* may be made advantageously of stone. The water-cistern, *h h*, is supported on two wooden beams, *m m*, at the top of the closet, by which the necessary elevation may be obtained. The dotted line *i i* indicates the line of direction of the water-pipe leading from the cistern to the soil-pan. In this form of water-closet the trap of the soil-pan may be dispensed with, by merely making the termination of the soil-pan in the form of a pipe, and leading it within a short distance of the bottom of the liquid-manure

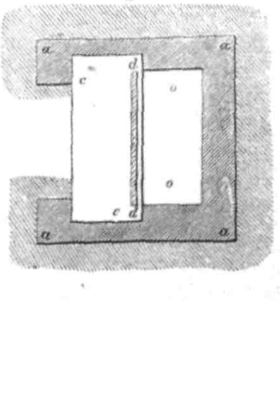
tank. In this case no foul air can escape up the tube, the aperture being always surrounded with water — the only surface from which smell could arise being the small portion at the bottom of the pipe; but in all forms of traps this exists. It is, therefore, essential to make this surface as small as possible, consistent with the insuring a free passage for the exuviæ.

Fig. 91.



A form of water-closet which has attracted great attention of late, is that known as Jenning's India-Rubber Tube Closet. It is especially deserving of the notice of architects and builders. It is perfectly noiseless in its action, effectually prevents the escape of effluvia from the trap, and is calculated to remain a long time in complete working order. The principal feature in the invention is an adaptation of an india-rubber tube, which, when compressed by the action of a simple lever, closes it, and *vice versa*; the action of

Fig. 92.



the lever, at the time of opening the water-way of the pan, opens the valve of the pipe from the main, or cistern: thus, the opening of the tube and the supply of water are simultaneous. Fig. 93 shows the tube open; fig. 94, shut.

Fig. 93.

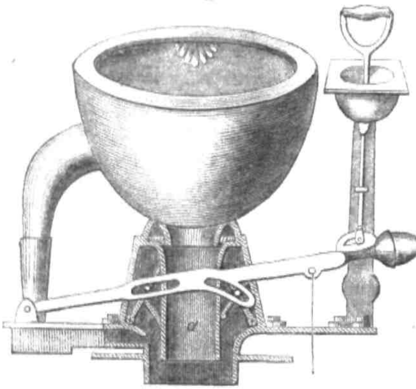
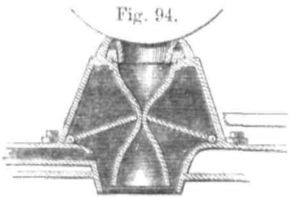


Fig. 94.



With the following extracts from the *Minutes of Information on House Drainage*, issued by the Board of Health, we close our remarks on this department:—" It is of advantage that the seat should be low, — lower than those in common use. The height of the seats of the common privies and water-closets is objectionable on physiological grounds, and the lower seat is also more convenient for children and young persons.

" In respect to materials, cast-iron pans are found to be objectionable; they oxidise rapidly by the action of wet and air. This bad quality is attempted to be remedied by glazing; but if there be any part of the glazing defective, or as soon as it becomes so, the pan is rapidly destroyed. The stoneware pottery soil-pans are free from these objections, and they are not liable to injury from frost.

" Where parties choose, either wood or cloth might be put over the seat, and it might have a double wooden cover on the principle of a seat in a frame to be lifted, and vessels emptied into the sink or trap without wetting the seat. It is desirable to dispense with wood-work as much as possible, not only on account of expense, but also because it is absorbent of filth and gases, and not so readily cleansed as earthenware.

"For cottages, not having in-door convenience for privacy, this apparatus can be easily adapted to the present privy building, so as to abolish the offensive and disgusting state of such places, described in every report presented to the Board, as among the most injurious and demoralising features of provincial towns. It is most important also that the apparatus should occupy but little space, so that it may be conveniently introduced amidst old and confined habitations.

"Arrangements should be made for cleansing the improved privies, urinals, and sinks in lodging-houses, by means of jets of water instead of the broom. For this mode of rapid and complete cleansing, earthenware will be highly convenient."

. . . . . .

"Whilst providing this soil-pan apparatus, provision for the covering of it, that is to say, for 'the privy, properly so called,' must, with respect to many neighbourhoods, be considered, so as to secure the means of privacy and decency.

"In suburban districts the cesspool and the privy are, in the fourth-rate houses, often placed at the end of gardens. When the cesspool is filled up, and the soil-pan apparatus substituted, one reason of the site of the privy being so far distant from the house will be obviated. The expense of carrying separate water-pipes and separate drain or discharge-pipes to so distant a site renders it ineligible.

"Privacy, but above all the convenience of the feeble and the sick, especially in inclement weather, require that the site, if not within the house, should be brought near to it.

"It is only when the house and main drainage is completely amended, and then with care, as recommended, that the apparatus should be brought within the house. The water-closet being generally placed at the back part of the premises, it is suggested for the consideration of owners, whether they could not in most cases form the privies on the outside of the back part of the house, with a communication through the back wall from the landing of the staircase, or elsewhere."

once from the surface of the earth, and those derived from springs intercepted in their course by the sinking of wells, &c. Spring water is that obtained from the clouds, falling on the surface and draining or forcing its way through the various kinds of soil until meeting one through which it cannot pass—as clay, or hard rock having no fissures; it forces its way through a convenient opening in the earth, and is obtainable there by simple methods. As in various sections of country the springs or streams of water percolate the soil at various depths, by sinking wells these may be intercepted; and, from a tendency to find its level, the water will rise; and if the level of its source is higher than the ground, it may be collected at the surface. In general, spring water is free from organic impurities, and this from its slow and gradual filtration through beds of suitable soil. The impurities of spring water are chiefly mineral, these being derived from the strata through which the water passes in its course to an outlet. In country residences the solid impurities in spring water are chiefly derivable from muddy particles, occasioned by careless lifting of the water from its outlet bed. If the spring should issue from the side of a bank at some distance from the ground, a pipe or drain-tile should be fitted to it, by which the water may run into the vessel without coming in contact with the soil at all. But in cases where the spring issues from the ground at or near its level, so that a very shallow depth of water is obtained before it finally runs away, it is almost impossible for a supply to be obtained by the usual means, without greatly contaminating the water with solid muddy impurities. In such cases as the above, it is no use to scoop out a hollow place in the bed of the spring—as we have sometimes known to be attempted—as in a short time it is silted up. A simple contrivance such as the following will be worth the outlay expended in placing it: Provide a stone trough, or a wood one—made in the manner hereafter described when treating of cisterns—some 12 or 15 inches deep, 2½ feet long, by 12 inches or so broad. Divide this by a water-tight partition, so that a space of 9 inches broad shall be left at one end, and of the depth of the trough. This partition should only reach to within 2 inches of the top edges of the trough. The bottom of the large division *must* be perforated with numerous holes. Dig a hole in the earth from whence the spring

SECTION SEVENTH.

WATER—ITS QUALITIES AND FILTRATION.

The sources from which water for household purposes may be obtained may be classed as three—Rain, Spring, and River.

Rain Water, when collected on pure surfaces, and descending through a comparatively pure atmosphere, is entitled to be considered the best we can obtain, and, from its solvent powers, is peculiarly valuable for household and detergent purposes. Rain water, in truth, in its purest state, is nearly equal to distilled water. One great objection to rain water as a *constant* source of supply for household purposes is, the decided affinity it possesses for organic impurities derived from animal and vegetable substances, everywhere predominant within the range of man's dwelling: hence the quickness with which rain water becomes tainted. This taint, fortunately, can be nearly altogether removed by filtering, and by keeping it from contact with the floating substances in the air. The conditions necessary to be observed in order to obtain an available supply of rain water, useful, as well for *drinking* as for cooking and detergent purposes, are these—first, The arrangement of a tank or cistern large enough to contain a quantity at one time, so that the over-abundance obtained in rainy weather may compensate for the deficiency occasioned by dry;—secondly, The keeping of the cistern in a cool and *shaded* place, well covered, so as to exclude the air and the filthy impurities suspended in the atmosphere—(light and air have been found powerfully predisposing agents to the propagation of animal and vegetable impurities); and the proper and careful filtration of the water before use.

The next source of supply is Spring Water, and in this we include the supplies obtained from springs which issue at

once from the surface of the earth, and those derived from springs intercepted in their course by the sinking of wells, &c. Spring water is that obtained from the clouds, falling on the surface and draining or forcing its way through the various kinds of soil until meeting one through which it cannot pass—as clay, or hard rock having no fissures; it forces its way through a convenient opening in the earth, and is obtainable there by simple methods. As in various sections of country the springs or streams of water percolate the soil at various depths, by sinking wells these may be intercepted; and, from a tendency to find its level, the water will rise; and if the level of its source is higher than the ground, it may be collected at the surface. In general, spring water is free from organic impurities, and this from its slow and gradual filtration through beds of suitable soil. The impurities of spring water are chiefly mineral, these being derived from the strata through which the water passes in its course to an outlet. In country residences the solid impurities in spring water are chiefly derivable from muddy particles, occasioned by careless lifting of the water from its outlet bed. If the spring should issue from the side of a bank at some distance from the ground, a pipe or drain-tile should be fitted to it, by which the water may run into the vessel without coming in contact with the soil at all. But in cases where the spring issues from the ground at or near its level, so that a very shallow depth of water is obtained before it finally runs away, it is almost impossible for a supply to be obtained by the usual means, without greatly contaminating the water with solid muddy impurities. In such cases as the above, it is no use to scoop out a hollow place in the bed of the spring—as we have sometimes known to be attempted—as in a short time it is silted up. A simple contrivance such as the following will be worth the outlay expended in placing it: Provide a stone trough, or a wood one—made in the manner hereafter described when treating of cisterns—some 12 or 15 inches deep, 2½ feet long, by 12 inches or so broad. Divide this by a water-tight partition, so that a space of 9 inches broad shall be left at one end, and of the depth of the trough. This partition should only reach to within 2 inches of the top edges of the trough. The bottom of the large division *must* be perforated with numerous holes. Dig a hole in the earth from whence the spring

issues, and put this trough therein, so that the upper edges shall be a little above the level of the ground. Ram tightly all round it stiff and good clay—the harder the better. The water from the spring will issue through the holes in the bottom of the large division of the trough, and any mud brought up will be deposited therein. As the clear water fills the trough, it will reach the top of the partition and run over it into the small division at the end, free from deposit. The supplies required should be taken from this division. In all cases where the spring issues at a level with the surrounding surface, this contrivance, or a simple trough with a perforated bottom, should be used, or a small *well* made.

The next source of supply to be noticed here, is that from RIVERS or RIVULETS. The water in these is derivable from two sources—rain water from the surface of the adjoining lands, and water from springs or land drains which may at various points run into the stream. The impurities in river water are apt to be numerous, both organic and mineral. Much depends upon the nature of the ground the river passes over. Granite is perhaps the best material, slate the next. Chalky soils produce deterioration of the water, particularly for detergent purposes—the *saline* impregnation rendering it *hard*, as it is termed. The *quality* of water depends upon the absence or presence of impurities; these may be classed as *mechanical* and *chemical*. By the former we purpose designating all muddy or solid particles held in solution—organic matter, whether derived from the "corrupting ingredients" of vegetable or animal production; and by the latter, the presence of salts and minerals in solution, or of gases derived from the decomposition of vegetable or animal matter.

Water obtained from rivers is most likely to contain in it muddy or solid particles; water passing over certain soils is very impure in this respect. Waters stored up from the surface drainage of land frequently contain mud, the loose particles of earth being conveyed by the drains. Water flowing over rocks, or gushing from a spring over and through a rocky or gravelly bed, is generally free from mechanical impurities. Solid impurities are generally taken from water by SUBSIDENCE and FILTRATION.

Filtration, as generally practised, is divided into two sections—filtration by SUBSIDENCE, and filtration by PERCOLATION.

In the former, the water is allowed to remain in a state of quiescence—the heavy impurities falling to the bottom, the superincumbent water remaining comparatively pure. In the latter, the water is made to pass through certain layers of substances called filtering *media*—these arresting and detaining the impurities contained in the water, which is allowed to pass off in a state of purity, proportionate to the efficacy of the filtering *media*. The filtration by subsidence, as may be supposed, when alone used, is very defective. The materials used in filters are very numerous—*sand*, *charcoal*, and *wool*, may be said to be the most frequently adopted. A sand filter, used as an oxidising agent, acts in proportion to its cubic contents. The layer of sand requires to be of considerable thickness, and should be washed before being used; this is requisite to free it from those finer particles which mix with the water passing through it, and are long held in suspension. This may be accomplished as follows: "Fill a bucket about three parts full of the purest water you can obtain, add a sufficient quantity of sand to raise the water to the edge of the bucket, stir it well together for two minutes, then let it stand perfectly still for about a minute; after this draw off the water. Repeat the operation some half-dozen times, or until the water drained off is as transparent as when it is added to the sand. The sand will then be fit for use." The charcoals, animal and vegetable, are also largely used in filters; they principally act chemically. Animal charcoal is a more valuable material for filtering than vegetable. Peat charcoal, so lately introduced with such marked success, possesses, in a remarkable degree, the absorbing powers which animal charcoal has been alone supposed to possess. As a filtering medium for water it has considerable advantages.

Wool, as a filtering medium, is often used—its chief advantage is its retaining its porosity for a length of time. It is purely a mechanical agent, arresting, between its interstices or pores, the solid matters contained in suspension in the water.

Mild and strong clays were found by Dr Hassall to possess remarkable purifying qualities. Urine passed through a filter of clay was found as clear and free from smell as the purest water. The researches of Professor Way, chemist to the Royal Agricultural Society of England, have been instru-

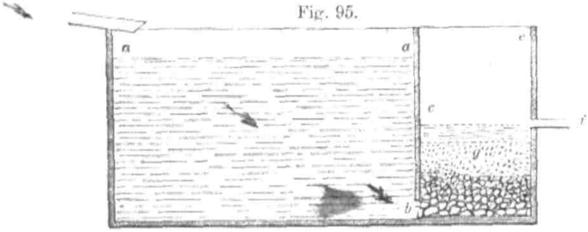
mental in proving that "clays and loams have powers of chemical action for the removal of organic and inorganic matters from water to an extent never before suspected." As a representative of pure natural clay, the Professor used what is called "plastic clay" for his experiments—better known as "pipeclay."

Filters are not only exceedingly useful for purifying water from organic impurities, but also, as we have seen, from various chemical gases and solutions. Their use in freeing water containing lead is remarkable. Thus a very simple practical means for separating lead wherever it contaminates water was discovered.

Having now noticed the process of filtration as briefly as the important nature of the subject has admitted, we proceed to the description of various kinds of filters for use.

In fig. 95 we give a sketch of a simple filtering-cistern, adapted for rain water, or where an intermittent supply is

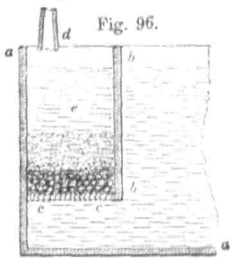
Fig. 95.



derived from a pump. A narrow division c, at one end of the large cistern, is made by a partition *a b*, as in the drawing. This partition must not quite reach the bottom, but a space be left through which the water can pass from the large division to the small one. The water to be filtered is admitted to the large division first, and passes through the aperture above noted, up through the filtering medium *g* and into *c e*, from whence it is withdrawn through the pipe *f*. As the water is drawn from *e e*, that in *a a*, from its tendency to find its level, will pass through the aperture *b*, and up through *g* as before. The filtering medium may be arranged as follows: First, in the bottom place a layer of clean round pebbles and pieces of broken earthenware; above this, small clean gravel, then coarsely pounded charcoal, a second layer of gravel, and lastly, clean sharp sand. A good filtering

medium may be made by placing a layer of gravel at bottom; above this a layer of coarse wool, then a layer of finer wool, and above these one of gravel. In place of having the position of the filtering medium as in the last, it may be situated in a box *b b*, fig 96, with a perforated bottom *c c*, the water being admitted to *e* through the pipe *d*: passing through the filtering medium, it will be delivered to the body of the cistern, from which it may be drawn free from impurities in the usual way. If a portable filter is required for spring, burn, or rain water, one made as in fig. 97 will be effective.

Fig. 96.



A water-tight box, *a a*, should have a stop-cock, *b*, to withdraw its contents at the bottom; it should be supported by legs, *c c*, sufficiently long to raise the box so as to allow a vessel to be placed underneath the stop-cock *b*, to receive the filtered water. Provide a zinc box, *d d*, or one made of wood, lined with gutta-percha, similar to that in fig. 98. This box should have a perforated bottom, and a bead, *b b*, at the upper edge, or other contrivance so as to prevent it from going into the box *a a* farther than requisite; the box may have handles, *c c*, to lift it out and in. The filtering medium should be arranged in the bottom of this box as in the sketch: the water admitted to it passes through the filter and into the part *e e* of the outer box; nearly the whole of the box *a a* may be made available water-space by placing the bead or ledge of the filtering-box near the bottom, which will keep it farther up in the box *a a*. By adopting the plan sketched in fig. 99, a still more simple and inexpensive water-filter may be made. A large flower-pot, *a a*, is provided with a plug *c*, or stop-cock, by which the filtered water may be drawn off; a circular

Fig. 97.

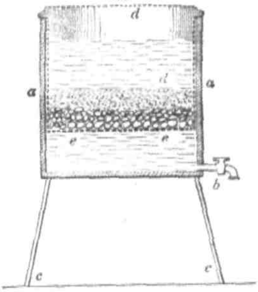
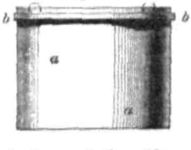
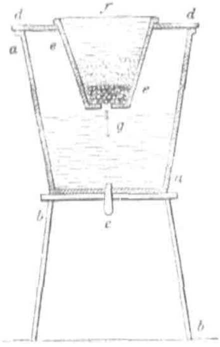


Fig. 98.



frame of wood, *d d*, of a little larger diameter than the pot *a a*, should lie on the top ledge. This frame has a hole or aperture in the centre, of size sufficient to allow a smaller flower-pot, *e e*, to pass down into the interior of the large one, yet to hang by its ledge or rim, as in the drawing. The whole apparatus is supported on legs, *b b*; the filtering medium is placed in the small pot, and the water passes through this from *f*, and is delivered to the interior of the large pot, from whence it is withdrawn by the plug or stop-cock *c*. The solid "charcoal filters" recently introduced are in every way efficient.

Fig. 99.

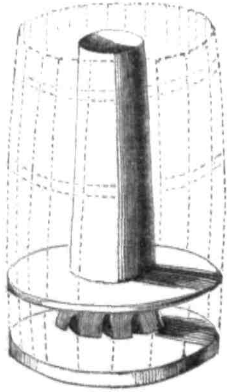


The Reverend Mr W. Law, of Marston Rectory, Welford, has designed a filter for domestic use, which is very simple in its construction, and, we believe, most effective—the filtering *media* being so arranged that their interstices are not liable to be clogged up.

For the accompanying diagrams and description we are indebted to the pages of the *Domestic Economist*.

"A chimney-pot made of burnt clay, and procurable at almost any brick-yard, free from flaws, and waterproof at the sides, is provided with five or six angular openings, about 5 or 6 inches broad, at the base, as in the sketch, fig. 100.

Fig. 100.



"A circular piece of oak board an inch thick, with a central opening sufficiently large to admit of its being fitted close to the outside of the chimney-pot, is placed at the distance of 6 inches from its base. This board is pierced with a number of holes, and should have a projecting width of 6 inches. The chimney-pot and its appendage stand in a cylindrical tub, or barrel, the internal diameter of which corresponds with the

circular oak-board. A white metal tap is fixed into the barrel, about 10 or 12 inches above the perforated board. The filtering medium which rests upon the circular wooden strainer is composed, first, of a 2-inch layer of fine well-washed gravel: upon this is placed a $\frac{1}{2}$-inch layer of coarsely pounded charcoal, then from 3 to 6 inches of well-washed river sand (the thickness of which stratum must depend upon its coarseness). The filter would now be complete, were it not for the tendency of the water, with which the inner cylinder is filled, to displace, by the force of its ascent (always proportionate to the height of the water in the inner cylinder), the last stratum. To obviate this, I lay upon the sand a piece of coarse linen cloth of double thickness, and upon this a 2-inch stratum of gravel, similar to the first layer. The height of the chimney-pot I use is about 5 feet; but there are various sizes. I conceive a cylindrical vessel, made of good Roman cement, would answer the purpose equally well. The operation of this filter is too manifest to require further description."

We have now to take into consideration the next department under this head—namely, the "Softening of Hard Water." In many districts the only supplies of water available are what are termed hard. We have already shown how important it is, so far as regards health and economy, to have soft water for domestic purposes. A knowledge, then, of the method of rendering hard water soft is desirable, where these requisites are considered worth attending to.

The hardness of water is generally tested or recognised by the difficulty there is in making a soap-lather with its aid. In the great majority of cases the hardness of water is caused by the presence of chalk in solution. Dr Clark has patented a method of freeing water from this impurity as simple as it is efficacious: it is now the universally received method of softening hard waters.

As this process is patented for Great Britain, it cannot be carried out on a large scale for public purposes without incurring the risk of a prosecution for "infringement;" but it can be imitated in the Colonies on a small scale for family use, by using lime-water. About a gallon of strong lime-water may be kept in a well-stoppered bottle, to be used when required: this quantity will soften a large amount of water. The fol-

lowing are the advantages claimed by Dr Clark, which will on trial be fully borne out :—

"1st, The water will be much softened, and to such a degree that, in lieu of from 24 to 32 ounces of the best curd soap being required to form a complete lather, with 100 gallons of the water supplied by the London Companies, a *similar lather may be produced by about one-third of the soap*, with 100 gallons of the same water purified by the trial process. 2d, The new process will prevent fur in boiling. 3d, It will separate vegetating and colouring matter. 4th, It will destroy insects. 5th, It is remarkable as a chemical process for *merely withdrawing* matter from solution in water *imparting none*."

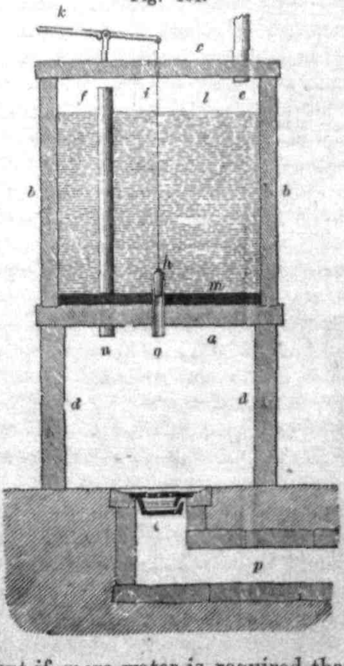
The following is the method recommended by Mr Holland for using the lime-water: Two jugs are to be provided, one holding thirteen times as much as the other. Fill the smaller one with a saturated solution of quicklime (lime-water); put this quantity into the larger one, and fill it up with the water to be purified, and mix the two together. The chalk is slowly deposited, and the clear water filtered for use.

SECTION EIGHTH.

CISTERNS.

In fig. 91 we have given a plan suggestive of a method of constructing a cistern, forming part of the outhouse, and in fig. 95 another sketch of a filtering cistern. We now offer an arrangement recommended by Mr Stephens in the *Book of the Farm*, to which we are indebted for the description and illustration.

Fig. 101.



"Let *a b c b*, fig. 101, be a cistern of stone or wood, placed at a convenient spot of the steading or farmhouse for the reception of rain water. I found that such a cistern, of the capacity of 12 cubic feet, holds a sufficient quantity of rain water for the domestic purposes of an ordinary family. A cistern of 2 feet square at the base, and 3 feet in height, will just contain that quantity; but, as the size of an ordinary wash-tub is 2 feet in diameter, the space between *d* and *d* must be made 2 feet 6 inches at least, and the height of the cistern *b* would be 2 feet; but if more water is required than

12 cubic feet, then the height should be 3 feet, which gives a capacity to the cistern of 18 cubic feet. Suppose the cistern represented in the figure to contain 18 cubic feet, then the area of *a* will be $2\frac{1}{2}$ feet square, and *b* 3 feet in height, supported on two upright stones, *d d*, of the breadth of the cistern, and 2 feet high. The cistern may either be made of a block of freestone hewn out to the dimensions, or of flags, of which the sides are let into grooves in the bottom and into each other, and imbedded in white lead, and fastened together with iron clamps, having a stone movable cover *c*; or it may be formed of a box of wood, securely fastened at the corners to be water-tight, with a cover of wood, and resting on the stone supports *d d*. Stone, being more durable, is of course preferable to wood for a cistern that stands out in the open air. A hollow copper cylinder *g* is fastened perpendicularly into the bottom *a*, having its lower end projecting 1 inch below, and its upper 3 inches above, the respective surfaces of the bottom. The upper end of the copper cylinder is formed to receive a ground truncated cone of copper *h*, called a plug or stopper, which is moved up and down with a lever *k*, by means of the copper rod *i*. The plug *h* must be made water-tight with grease, the rod of which passes through a hole in the cover, to be connected with the lever *k*, whose support or fulcrum is fixed on the cover. These parts are all made of copper, to withstand rusting from the water, with the exception of the lever, which may be of iron, painted. The rain water is supplied to the cistern by the pipe *e*, which descends from the rain-water conductor, and is let through a hole in the cover. The water is represented standing as high as *l*; but in case it should rise to overflow, it can pass off by the lead waste-pipe *f*, which is secured and movable at pleasure in a ground-washer *n*, whose upper end is made flush with the upper surface of the bottom *a*. After the water has entered the cistern, it gets leave to settle its sediment, which it may do to the height of the upper end of *g*. The sediment is represented by *m*, and when it accumulates to *h*, the cover *c* should be taken off, and the waste-pipe *f* removed, and the cistern cleaned completely out by the washer *n*. The waste water runs away through the air-trap *o*, and along the drain *p*. It is more convenient to have two small than one large cistern—as, while the water is rising in the one, that in

the other gets leave to settle. The cost of such a cistern, with droved stones, and to contain 18 cubic feet, with the proper mountings, may be about £5. I think it right to say, in commendation of this form of water-cistern, that in no case have I known the water about the plug to be frozen, in consequence, perhaps, of the non-conducting power of the mud in the bottom of the cistern. The rod *i* has sometimes become fast to the ice on the top of the water at *l*, but a little boiling water poured down by the side of the rod through the hole in the cover, by means of a funnel, soon freed it from restraint."

A barrel will form a very excellent water-cistern. It should be slightly charred in the inside: this will prevent the wood from rapidly decaying, and it tends to keep the water sweet. The charring will be easily effected by burning a few chips and shavings in the interior. The water can be withdrawn from the cistern by means of a simple cock, or even more simply by withdrawing a plug driven into an aperture in the side of the cistern, about 6 inches above the bottom level.

SECTION NINTH.

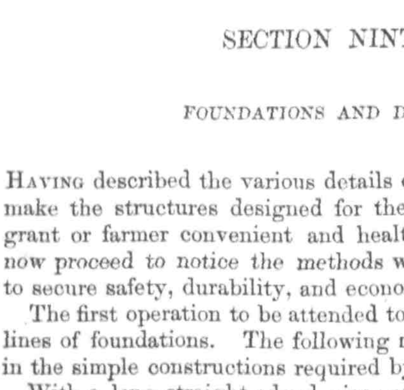
FOUNDATIONS AND DRAINS.

HAVING described the various details considered necessary to make the structures designed for the habitation of the emigrant or farmer convenient and healthy in *arrangement*, we now proceed to notice the methods which may be employed to secure safety, durability, and economy in *construction*.

The first operation to be attended to is the marking out the lines of foundations. The following method may be adopted in the simple constructions required by the settler:—

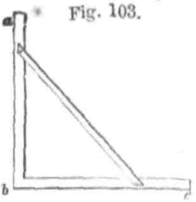
With a long straight-edged piece of wood, or a stout cord, mark along the ground a line *a b*, fig. 102, corresponding to the front line of house. Take the square, fig. 103 (the method of constructing which will be described under the head of CARPENTRY), make the line *b c* lie along or coincide with the line *a b*, in fig. 102; and the point *b*, fig. 103, with any point on the line *a b*, at which the corner of the cabin is desired to be placed, as at *d*: along the face *a b* of the square draw a line *d e*, fig. 102, and continue it to *e*, or beyond. Suppose the breadth outside of the cabin is to be 12 feet, with the measuring-tape mark off from the point *d* 12 feet to *e*. Make the point *b* of the square correspond with the point

Fig. 102.



e, fig. 102, and the line *b c* with the line *d e*, fig. 102, and along the side *a b* of the square draw a line to *f*. As the length outside is to be 18 feet, from *c*, fig. 102, measure to $d = 18$ feet. Make the line *b c* of the square lie along *a c*, and the point *b* correspond to the point *c*; along the side of the square *a b* draw a line to *f*; make $c\ f = d\ e$; an oblong *d e f c*, 18 by 12, will thus be marked out on the ground, serving as a guide for digging the trench to form the foundations. The trench may be dug 18 inches deep and 2 feet wide; the centre of this trench will form the centre of wall. Thus, if the thickness of foundation at bottom is to be 18 inches, a space 9 inches on each side of the marked lines will be required. The depth of the trench will depend on the nature of the soil; when it is very strong and firm, from 9 to 12 inches will be sufficient. The thickness or breadth ought to be twice that of the walls. This, however, will depend very much upon the soil; if in soft and loose ground, it is evident that they should be thicker than when it is hard and soft. Generally the proportion of foundations to walls is as above—two to one. The requisites for good foundations are, means for preventing inequality of settlement and the escape laterally of the supporting materials. The bottom of the trench should be perfectly level; and to effect this, the spirit and common mason's level should be frequently used in the course of the work. A rocky foundation is the best as regards dryness; a gravelly soil the next. The preparation of a rocky foundation is, however, so tedious and expensive—as a settler's time is money—that in all cases where a gravel bed can be obtained it should be adopted as the site, even where its other advantages are not so obvious. Clay offers many advantages as a foundation; blue lias, when first opened up, appears sound and firm, but rapidly gives way under the influence of air and moisture. The sooner foundations in clayey soils can be finished and filled up the better. In all cases the nature of the ground to be built upon should be tried, as it often happens that a good firm soil is supported upon a very treacherous stratum beneath. If a stratum of peat or boggy matter should be beneath the sound upper

Fig. 103.



crust, as the drainage of the site will withdraw a portion of the moisture, the peaty substratum will subside, and allow the walls above to settle. In such a case we should advise the settler to look out for a more stable foundation, as the methods to secure a good one in this case are too tedious, and come too much under the head of complex operations to be carried out by him, lacking, as he is supposed to do, the necessary time and materials. It sometimes happens that a foundation trench, when dug, will present here and there places of soft and shifting material; in such cases the best method is to excavate holes in these situations, for a few feet of depth, and fill them up with good gravel, sand, or small stones, to the level of the bottom of the trench. In loose soils the unequal settling, as injurious to the stability of the walls, can be best prevented by digging the trench deeper than would otherwise be required, and laying up to the level of the footings courses of loose stones, with concrete (see LIMES), or grout poured between them. In the case of foundations for a log cabin all that is necessary to be done is to dig the trenches some 18 inches deep, and same wide, filling in loose stones of size sufficient to pass through a ring of 4 inches diameter, up to a level of 5 or 6 inches of the top of the trench; the logs, say of 16 inches square, are then to be placed in the centre of the trenches, and the space between the edges of the log and the sides of the trenches well rammed in with small stones. This foundation will last long enough to enable the settler to progress in his style of life until he can command a more durable structure than a log shanty. If the logs forming the foundation can be well painted over with tar, mixed with sand, in the proportion of three parts of the former to one of the latter, they will be preserved much longer than if not finished in this manner. For "pisé" houses the foundation may be made in the manner as above: in brick and stone houses the breadth of wall at the foundation is generally made twice that of the wall above. In brick walls the course immediately beneath the wall projects a quarter of a brick beyond it, the course beneath this a quarter of a brick beyond the top course, and so on. For ordinary houses two courses are left beneath the wall, as in fig. 104; and in some instances three, as in fig. 105. In this example the last course is left above-ground, the line *b c* being its level, a bevelled or splayed

brick being placed at *a*, in order to throw off the water. Where stones are used for the walls, a simple foundation, where the substrata are good, may be constructed as in fig. 106, a trench *a b c d* being cut of twice the width of wall *f*, and same depth, the sloping foundation *e* being made of flat stones, the corners being well rammed up with small stones. Mr Stephens describes a method of making the foundations of cottages, which we illustrate in fig. 107, "where *a* is the pavement of the floor of the room, resting upon broken stones to keep it dry; *b* the broad gravelled footpath along the front of the wall; *c* the surface of the ground on the road, some inches below the level of the footpath; and *d* the drain to carry away the water that may chance to fall upon the footpath. A border of earth may be made along the front of the house, and a fence of low hedging placed between it and the footpath, which in that case would be made where the road *c* is."

Fig. 104.

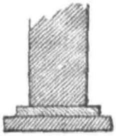


Fig. 105.

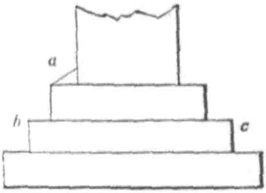


Fig. 106.

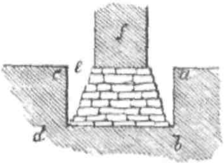
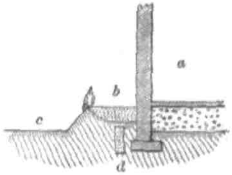


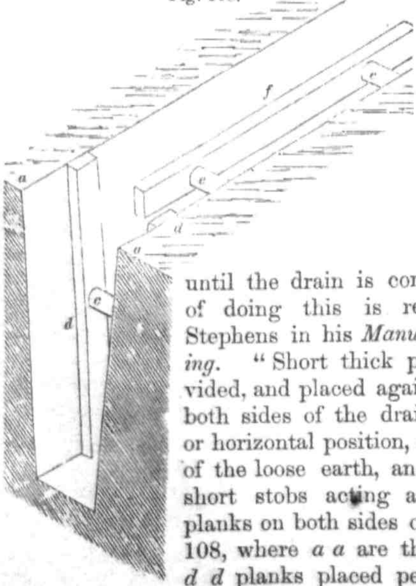
Fig. 107.



DRAINS are important appendages to a well-constructed house, where the health of the inhabitants is desiderated. Other things being equal, a damp house may be said, with certainty, to be an unhealthy one. The best way to secure dryness is by having the site well drained. We shall here present a few hints for the guidance of those who may wish to carry out this important matter: but as the means and materials at their command are supposed to be limited, we shall make these hints as simple in their character as possible, so that the plans therein embodied may be carried out

without much trouble or delay. Premising that the drains for conducting the water from the site of the house are to lead to some pool, rivulet, or ditch, at some distance from the house—and those conveying the refuse water of domestic operations, &c., to the liquid-manure tank (for the construction of which see FARM BUILDINGS)—the first operation to be attended to is the laying out of the line of drains. This should be as straight as possible, avoiding all curves or bends. Where these are absolutely necessary to change the direction of the drains, curves should be adopted, and of as large a radius as possible, using in no case right-angled turns. The excavations, in which to lay the drains, should be made wide enough to admit of a man's easy descent to build them. The excavation should have a slope from beginning to end. The incline should be, for every 20 inches in horizontal length, 1 inch of vertical descent. If the point of exit of the drain is at some distance from its commencement, the depth of excavation at exit will be considerable, from the amount of fall throughout its length; some means, therefore, will be required to keep the sides from falling in until the drain is constructed. A method of doing this is recommended by Mr Stephens in his *Manual of Practical Draining*. "Short thick planks should be provided, and placed against the loose parts of both sides of the drain, in a perpendicular or horizontal position, according to the form of the loose earth, and there kept firm by short stobs acting as props between the planks on both sides of the drain, as in fig. 108, where *a a* are the sides of the drain, *d d* planks placed perpendicularly against them, and kept in their places by the short prop *c*, and where *f* is a plank placed horizontally and kept secure, opposite

Fig. 108.



another plank similarly placed, by the props *e e*." The simplest of all drains is that shown in fig. 109, which is filled with stones. These are best obtained from the channel of a river, or the sea-beach, and should be of a round form, and as uniform as possible in size. Stones of various sizes, large and small, should not be used. Where the stones have to be broken on purpose, they should be assorted, round, and uniform in size. After the stones are filled in, the layer near the top should be well rammed down with a heavy wooden beater, made out of part of the trunk of a tree, with one end squared, and the other having a handle attached to work it with. Drains may be constructed of flat stones, as illustrated in fig. 110. The drain is filled up by two flat stones *h h*, $1\frac{1}{2}$ inch thick, meeting at the bottom *g*; they are kept asunder by a large stone acting as a wedge. The drain above this is filled up to *e* with small stones. Another form is shown in fig. 111, where

Fig. 109.

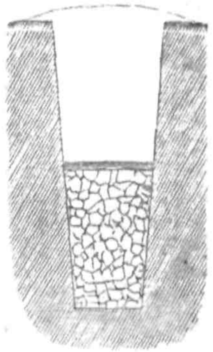


Fig. 110.

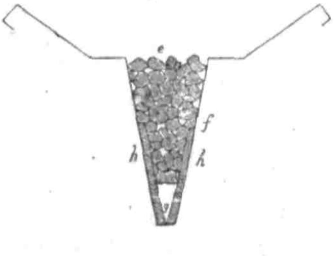
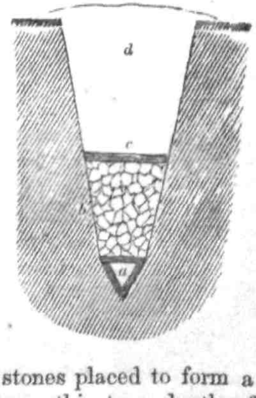


Fig. 111.



the water-duct *a* is formed of three stones placed to form a triangle; small stones are placed above this to a depth of 12 inches; a turf or other dry substance *c* is placed over these, and the earth returned above all at *d*. The drains we

have described are all adapted for conveying water from the site of the house, or for draining of lands, having the sides permeable—that is, through which the water from the surrounding soil can percolate to the interior. In the drains used for conveying refuse water from domestic operations, this quality of permeability is not required; on the contrary, the drains throughout their whole length should be, if possible, water-tight, and as smooth in their interior as possible. The sooner the liquid manure is conveyed from the house to the place of deposit, or the liquid-manure tank, the better. Drains are best constructed of the circular earthenware drain-tubes, with conical or socket joints; but as these are not likely to be easily obtained by the settler, a very good form of drain may be made of timber, as in fig. 112, having the lower corners rounded off as in the diagram. As the timber will be always moist, it will last a long time—the alternations between wet and dry being that which causes timber, when placed in the ground, to decay speedily. Timber drains are much used in Sweden, and found successful. As the gases evolved from the sewage matter are prejudicial to health, the drain leading to the liquid-manure tank should be "trapped" at the entrance nearest the house, as at the sink or slop-stone in the scullery or kitchen.

Fig. 112.

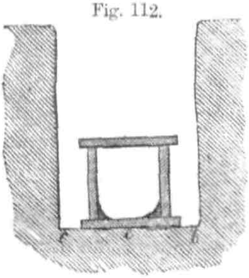
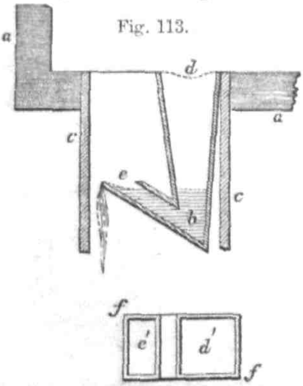


Fig. 113.



A simply made form of "trap," of wood or metal, is illustrated in fig. 113. Let *a a* represent part of the sink, *c c* the pipe leading to the drain, *d e* the trap, of which *f f* is a plan; *d d'* being the end through which the liquid passes from the sink, and

e e′ that through which it leaves to the drain. An inspection of the figure will show at once the way in which the trap is constructed. A perforated cover *d′* being put at the end *d*, this cover may be made to hinge at one side: by opening this, any solid matter collected at the angular part of the trap may be removed. An examination of this form will best convey the principle of the construction of traps. In all of them, the exit aperture is made at such a level that the liquid always remains to cover that part of the trap round which the foul air must necessarily go, before ascending the trap. This ascent of the foul air is thus prevented so long as the water is at the proper level. Thus, the angular point *b* in fig. 113 being surrounded with water, the air entering by *e* cannot possibly pass out at *d*. In process of time, the solid matter is apt to deposit itself in the bottom part of the trap, and by this means to render it ineffective. This deposit should from time to time be removed; and, to facilitate the operation, the perforated covers should in all cases be movable. In traps where no great quantity of solid matter is held in the water passing through the trap, an occasional mass of water sent down will effectually prevent any undue deposit. The distinctive feature of traps for all such purposes as drains and sinks being kept in mind, the modifications in construction and arrangement may be very numerous. The last one we have figured may be made for a few pence.

The illustrations of house drains and traps which we have here given, are of the simple character fitted for the structures of the emigrant settler. We now give a few of the appliances used in modern sanitary construction. Fig. 114 shows a drain constructed of bricks with angular bottom. Fig. 115 shows a drain constructed with the horse-shoe drain-tiles—*a* the lower tile, covered by an inverted tile *b*. Fig. 116 is a sketch of Clayton's Drain-Tube, with improved socket flush-joint. Fig. 117 shows the method of joining drain-tubes by the spigot-and-faucet

Fig. 114.

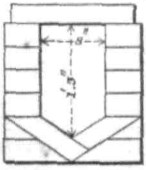
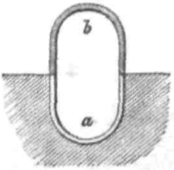


Fig. 115.



joints: the tube *a a* is inserted so as to join to the tube *b b* —clay being rammed into the space *c c*, to secure a water-tight joint, if required.

Fig. 116.

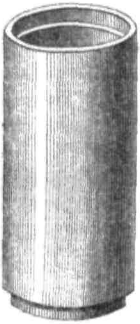
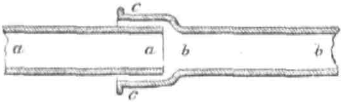


Fig. 117.



Figs. 118 and 119 show forms of Austin's Rabbeted Joints for drain-tubes. The difficulty of removing any one part of the length of drain-tubes laid by any of the usual methods, in order to remove obstructions, without disturbing the whole, has led to the invention of several methods to obviate the difficulty. One of these we illustrate in fig. 120: the plan is patented by Mr Cooper, of Poole, Dorset.

Fig. 118.

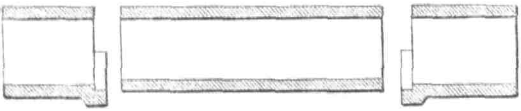


Fig. 119.

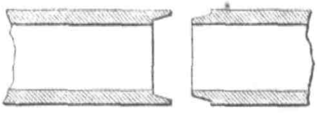
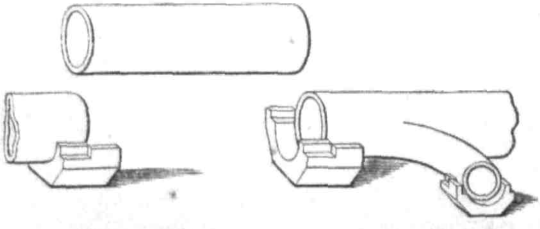


Fig. 120.



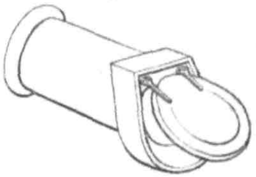
"The following are some of the advantages secured by their use: They provide ready access to any part of the drain, for

examination, without disturbing any other part, or point of the invert, of the drain. The pipe, being laid on the under connection, butts the adjoining pipe at the middle of the connection; the pipes are therefore kept perfectly straight in the drain. Should any pipes be not quite exact in size, arising from the difference of the shrink in burning (which is often the case), their being joined on an even surface at the middle of the under connection, will necessarily throw any irregularity to the top of the drain, thereby obviating the necessity of the use of the mop, and making the invert perfectly fair and even, not liable to be obstructed or injured by running sand, sinking of the earth, or the action of external water. By the use of the under connection singly, the full advantage that half sockets, single or double, may be considered to be, is secured to every pipe."

In fig. 121 we illustrate a form of "earthenware trap," and in fig. 122 the "flap-trap" and drain mouth.

Fig. 121.

Fig. 122.



SECTION TENTH.

SOLID GROUND-FLOORS.

The following is Mr Roberts' plan of forming hard, cheap, and durable floors:—" A foundation or substratum should be prepared about 6 inches thick, with coarse gravel, or brick-bats and lime-core, well beaten to a level surface. In damp situations, tar may be added to the concrete on which the ash-floor is to be laid, thus prepared: Take good washed sand, free from all earth and stones, together with the ashes of lime fresh from the kiln, in the proportion of two-thirds of sand and one-third of lime-ashes (where obtainable, the substratum of the third portion of smiths' ashes, or pounded coke for one-half of the sand, increases the durability and hardness of the floor); mix the sand and lime-ashes well together, and let them remain in a body for a fortnight, in order that the lime may be thoroughly slaked; then temper the mortar, and form the floor with it 3 inches thick, well floated, and so worked that it be not trodden till it has lain for three days, or according to the dampness of the weather, when it should be well rammed for several successive days, until it becomes hard—taking care to keep the surface level; then use a little water, and smooth it with a trowel; after this keep the floor free of dirt, and when perfectly dry it may be rubbed over twice with linseed oil, which gives the appearance of stone instead of sand." Where joists are used, a durable and cheap floor may be made as follows: Reeds are laid across the joists, or, if these cannot be obtained, laths may be used; these are laid close to one another, perhaps two or three deep; across these long laths are nailed to the joists, to keep the laths in their places. The plaster-of-Paris is then mixed and laid over these, spread with a large scraper, and levelled with a mason's level, till of a uniform thickness. To

aid in properly levelling, a horizontal line may be marked all round the walls of the room near the floor, according to the depth required. The plaster should be laid on first at the part farthest from the door, working all round till the door is reached. Smooth boards may be laid on the surface, on which to tread, in order to rub the plaster with a plastering trowel from time to time until it hardens. If any portion of such a floor is damaged, the piece may be taken out by means of a saw, and, putting reeds at the bottom, filling anew with plaster: the sides of the part taken out should be made to incline inwards, so that when put in, the plaster may, as it were, be dovetailed to the old flooring. A solid and lasting floor, that will be impervious to wet and impenetrable to rats, is made of mortar in the following way: Break a quantity of stones, so as to pass through a ring 2 inches diameter; lay these in an even layer on the floor to a depth of 5 or 6 inches; make a gravel-and-mortar concrete, with small gravel and newly slaked lime; pour this in a thin state equally over the stones to a depth of 2 or 2½ inches. When this layer has set, spread over it another layer about 1½ inch thick, composed of one part lime to two parts sand; just before this is dry, go over the smooth surface with a whitewash brush; this outer finish will last nearly as long as the floor itself. Where hydraulic cement can be obtained, it makes a first-rate floor.—(See Cements.)

SECTION ELEVENTH.

LOG CABIN OR SHANTY.

Having discussed the mode of constructing the *foundations*, *drains*, and *floors*, we now proceed to explain the various methods of erecting the *superstructure* of houses.

The cheapest and most simply constructed house which the emigrant, whose locality abounds in wood, can obtain is what is termed the "log shanty," of which a perspective view is given in fig. 123, and a plan, showing position of door *a*, window *b c*, &c., in fig. 124. The logs should be cut from the trees in lengths corresponding to the dimensions of the shanty or cabin. In the plan, fig. 124, the outside length is 18 feet, the breadth 12; these, then, will be the respective lengths to which the logs should be cut. Each log should be slightly squared or flattened with the axe or adze, on opposite sides, as in fig. 125. The simplest method of constructing the log shanty is by merely laying one log above another, in such a method as to secure a certain amount of bond or union between the various lengths; the other plan is to build up the logs within posts driven into the ground at certain distances. Having prepared the logs, the next operation is

Fig. 123.

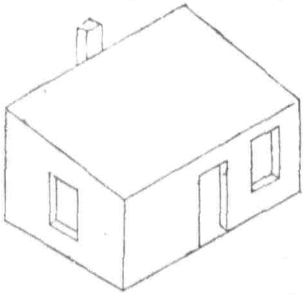


Fig. 124.

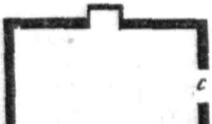
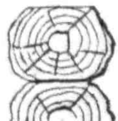
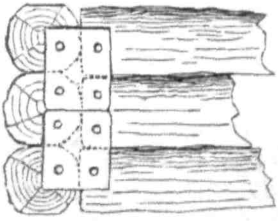


Fig. 125.



marking out the extent and position of the house upon the intended site. The first logs should be placed all round the trench, so as to form an enclosure, and the logs lie in the trench at least half their depth. By this arrangement, the first layer of logs will be above the ground, so that if planks are used to form a floor resting on the logs, a distance will be left between the ground and under side of flooring; by this means the floor will be freer from damp than if merely resting on the ground. On laying the second tier of logs, the opening for the door begins to be formed: this is effected by laying down logs of such length that they will reach only to a certain mark, previously made on the log beneath—or the logs may be laid the whole length of the front of the cabin, and a space cut out by the saw. The simplest method of keeping the logs in their places is by spiking them together at the corners, and at the faces left by cutting out the doors and windows. This spiking may be done by large iron nails, or by driving in trenails of oak, or other suitable wood, the holes for which must be made by means of an auger.—For method of making and using trenails, see CARPENTRY. In place of using the simple nails or trenails, the logs may be kept together by the method shown in fig. 126, where the "bond" is obtained by pieces of flat board secured by nails or trenails at the corners. In addition to this method of securing bond, the method of laying the logs alternately may be adopted, with the certainty of insuring greater firmness of the structure. This system is shown in figs. 127, 128, which, by the aid of the corresponding letters, will be sufficiently explained. The logs should be piled one above another in front to the height of 8 feet, and at back 10 feet. The roof is supported by timbers; the method of placing which will be described in CARPENTRY. The mode of arranging the lengths of log to form the slope of the roof is explained in fig. 129. Let *a b* represent the uppermost log when the building is raised to a uniform height of 8 feet all round; nail at each end, at the back of wall, a perpendicular rod *c d*, 2 feet high; from *c*, to the

Fig. 126.



top of this place, another rod *e d*; this will give the slope of roof. After this is obtained, the fitting-in of the logs of

Fig. 127.

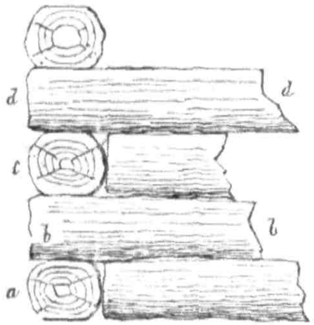
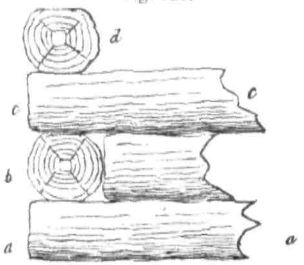
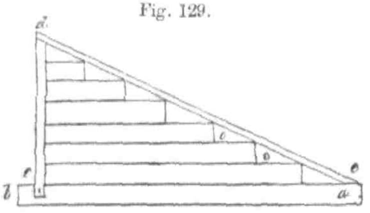


Fig. 128.



the requisite length is an easy matter: the triangular spaces, as *o o*, may be filled in with spare pieces of wood. The chinks between the logs forming the house should be filled up with small chips and well-kneaded clay.—For methods of covering the roof, and finishing the exterior of the cabin, see ROOF AND EXTERIOR FINISHINGS.

Fig. 129.



The fireplace in a log-cabin, such as we have illustrated in fig. 124, should be built *outside*, a *hole* being cut out of the logs at the floor level to form the opening to fireplace. If the emigrant possesses a stove, the fireplace may be omitted—the tube or smoke-pipe being led through an opening in the roof—care being taken to make the hole in the roof much larger than the diameter of pipe, so as to admit of a quantity of well-kneaded clay being passed round the tube: this will prevent the wood forming the roof-covering catching fire from the tube, which now and then may get overheated. Where a stove is not obtainable, it will be necessary to build a fireplace. This will be safest and most convenient when built with bricks; but on the supposition that

these evidences of a more advanced civilisation are not attainable at this stage of his emigrant life, we think it best to explain to the settler an easy method of constructing one by the aid of materials which may reasonably be supposed to be within his reach—namely, some short pieces of bar iron ½ inch diameter and 15 inches long, well-kneaded clay, and pine planks. Let *a a*, fig. 130, be the logs forming the back of cabin, with a space cut out to form fireplace 2 feet 6 inches in width and 3 feet high; a box 3 feet 3 inches deep, 2 feet 9 inches long, and 18 inches wide, having three sides and no bottom or top, should next be made, as *d d e*, and secured firmly, with open side inwards, to the logs outside. A board *c*, covering the whole of the opening of fireplace in the inside of the cabin, must next be firmly secured to the logs. The space thus formed must be well rammed with soft gravelly soil, or well-mixed clay. When the filling up is completed to the level of the top of the box *d d e*, the board *c* is removed, and a space cut out of the hard rammed clay of the shape as at *b* in fig. 130, and *c*, fig. 131. The grating and front bars will be made by inserting the lengths of iron rods in the manner shown in fig. 131. The space *c* will be deep enough to admit of the ashes lying. The hearthstone usual in houses may be dispensed with, but should be laid down if at all obtainable; or a slab of well-beat clay laid before the fireplace may be substituted. The method of making the smoke-flue is illustrated in fig. 132. A continuation of the box *d d e*, fig. 130, is continued to a distance of 2 feet or so above the roof. A length of the trunk of a young tree, as straight and round as can be obtained, must

Fig. 130.

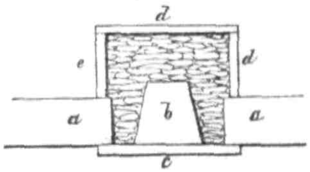


Fig. 131.

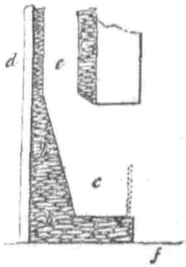
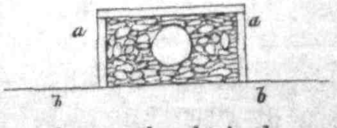


Fig. 132.



be put into this box, the narrow end downward; the diameter should be as equally the same throughout as possible, about 10 inches; the narrow end should be cut square off, and so placed as to be above the fireplace, fig. 131, that the communication between it and the chimney to be formed may be easily made, as in the diagram, and space left between the outside of logs and inside of box *a a*, fig. 132, that, when the clay is rammed firmly down, it may surround the pole on all sides. Before beginning to ram the clay in the box—which must be well secured together to prevent its bursting by the pressure of the clay—the pole should be well wetted, which, together with its being placed small end downwards, will facilitate its removal when the clay is properly packed without disturbing it. The part of the box above the roof must be furnished with four sides, the logs forming the fourth side of the part below. In fig. 131, *f* is the line of floor, *d* the logs forming back wall, *e* the flue. Where unburnt bricks can be readily made (see BRICKMAKING), the chimney may be built with these. The sketches of fireplace now given are drawn to a scale of $\frac{1}{4}$ inch = 1 foot. It may be as well to mention, that although we have preferred the roof to slope towards the front, as in our sketch, as looking better, log shanties are generally built the reverse way—the proportions of height being, front wall 9 feet, back 7: in this matter the settler can please his fancy. We have next to notice the method of building log shanties in which posts are used. The construction is very simple, and will be more secure than the method we have described. The posts are to be driven into the ground at proper distances, corresponding to the opening of doors, &c.: they should be driven so as to have a depth of at least 30 inches. The operation of placing them will be much facilitated by previously digging holes to the depth of a foot or so, driving them in 2 feet, filling up the hole, and finally driving wedges, some 15 or 20 inches long, close round the foot of posts; the head of these wedges being, when fully driven home, flush or level with the ground. The ends of the posts should be pointed, and charred or burnt slightly on the outside: this will prevent the damp rotting them for a time. When the posts are properly placed, and of a uniform level at the front and ends, the back being higher, the spaces between are

filled in with logs, having the two sides levelled slightly, as in fig. 125, and firmly spiked or trenailed, as shown in fig. 133.

Fig. 133.

For economical and simple methods of making "floors," see remarks in the Section on that subject. For the various details of making joints in timber, roof timbers, &c. &c., see CARPENTRY; and of making and fitting up interior finishings, as doors, windows, fireplaces, &c., see JOINERY.

SECTION TWELFTH.

FRAME-HOUSES.

This species of structure is only available by the emigrant settler who is located near a saw-mill, or who can erect one by which he may be provided with what in America is called "lumber"—that is, planks, &c. of various dimensions. The simplest frame-house which can be erected is by driving posts into the ground, and nailing what are termed slabs—that is, the outsides of logs sawn off, as in *a*, fig. 134—on the inside and outside faces of posts *c c*, the space between them, *d*, being filled up with some non-conducting material, as clay or earth, which will keep the interior much warmer than if the space is left hollow. In place of having the inner face of the posts covered with slabs, as in the sketch, folded canvass may be nailed to the inside of posts, which may be painted. If the settler happens to have a supply of asphalted cloth, or the waterproof felt which is now largely used for covering roofs in this country, a very snug and quickly-raised house or cabin may be constructed. All that is necessary is to drive a few posts *a a*, fig. 135, into the ground, the back row 2 feet higher than the front—the posts to be at distances not exceeding 2 feet, and 4 inches square. The felt *b b* is then to be nailed to the outside of the post, having a lap on the wood of at least 2 inches; cleets, or strips of wood, *c c c c*, fig. 135, is then to be nailed down the edge of the post *above* the felt. After this is done, the felt is to be stretched to the adjoining post, and fast-

Fig. 134.

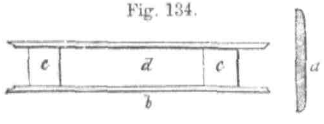
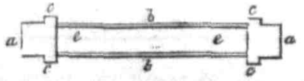


Fig. 135.



ened in the same manner. If a similar strip of felt is nailed in the inside of the posts, and the space *e e* between filled up with non-conducting material, a warm, comfortable cabin may be finished, ready for occupancy in two days' time. The roof is also covered with felt, laid on spars which should project at least one foot beyond front wall. The fireplace in this construction should be built wholly of brick or clay, and be outside the back wall. A stove, with the flue carefully led through an aperture in the roof, would be more convenient.

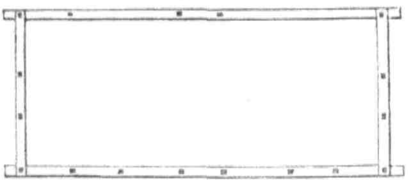
The simple frame-houses which we have described are to be considered merely of a temporary nature, and to serve only until the settler has so far progressed in his arrangements as to require the shelter of a structure having higher pretensions to durability of construction and elegance of appearance. We now proceed to detail the method of fitting up a frame-house of more complicated structure, and which, if properly carried out, will be durable enough to last the settler for a number of years. The foundations of all good frame-houses should be constructed of brick or stone, and carried all round to a height of at least 18 inches above the ground,—in this foundation the upright posts constituting the framing are built. In the event, however, of brick or stone-work for this purpose not being available by the settler, we think it best to explain, also, how a good log foundation may be made, which will last many years — premising that the after operations to be described are to be carried out in any case, whether the foundations be of wood, or of brick or stone. Having procured logs of from 12 to 16 inches diameter—partly square them on opposite sides, as in fig. 125; next mark out the outline of house on the ground, and make a frame of logs corresponding to this.—For method of joining the timbers at the angles, &c., see CARPENTRY. Having previously decided on the plan of house, ascertain the measurements of the distance of window and door openings from any angle, as at *b*, fig. 136, and mark them off on the log foundation, or frame, as to *c c*,

Fig. 136.

and at these places cut mortise-holes, to admit the mortised ends of the upright posts.—For description of these terms, see CARPENTRY. After all these holes have been marked and cut, the foundation frame, as lying on the ground, will pre-

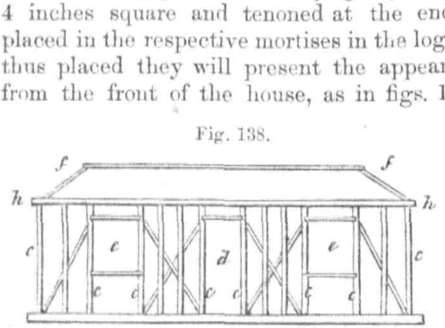
sent the appearance of the sketch in fig. 137, which is a ground-plan — the arrangement of the apartments and dimensions being as in the front part of fig. 17, having a living-room *b*, a bedroom *c*, lobby or porch *a*, and closet. The scale to which the sketches of the frame-house

Fig 137.



now under consideration are drawn, is $\frac{1}{16}$th of an inch to the foot. Having provided the upright posts of requisite length, 4 inches square and tenoned at the ends, they are to be placed in the respective mortises in the log foundation. When thus placed they will present the appearance, when viewed from the front of the house, as in figs. 138, 139. The upper timbers *h h*, 9 inches square, must be placed on the top of the posts *c c*, the tenons of these going into mortise-holes in the timber; or notches

Fig. 138.

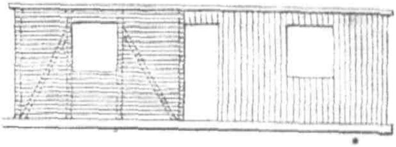


(see CARPENTRY) may be made on the under side of *h h*, and spiked to the posts: the office of these timbers, *h h*, is to support the spars forming the roof *f g*. The upper part of the window and door frames *e e d* must next be put in between the posts (see CARPENTRY); and struts, 2 inches broad by 1 thick, placed as in the sketch. Where great strength is not required, as in the case of a one-storied house, these struts may be dispensed with; but where there is a bedroom story, they are indispensable. The lower part or sill of the window-frames, *c c*, must next be put in. The fire-places and flues should next be constructed of brick or stone, and the flues continued through the roof-timbers, and properly

Fig. 139.

finished at top. The spars *h f h f*, forming roof (see ROOFS) are next to be laid down, and properly secured; and finally, the shingles, slates, tiles, &c., used for the roof-covering laid carefully on. The outside covering of walls comes next under consideration. This is generally effected by nailing planks some 6 or 9 inches broad by 1 thick, either vertically or horizontally, as exemplified in fig. 140.

Fig. 140.



We prefer to place them vertically, as to the left of the sketch: where they are laid horizontally, they overlap one another in the manner shown in fig. 141. The sketch to the left is a front view; the dotted line in that to the left represents the outside line of post to which the boards are nailed. In securing these, the one nearest the ground is nailed first, the second is placed so as to overlap this, the third to overlap the second, and so on: by this arrangement all the joints are secured from the effects of the weather. Where the boarding is secured to the posts vertically, the planks are nailed to the top and bottom timbers, between the posts, edge to edge. In first-class work they are tongued and grooved (see JOINERY), but in ordinary work they may be merely planed, or, if preferred, left rough. The joints between the boards *a a*, fig. 142, are covered by narrow strips or battens, *b b*, some 2 inches broad and 1 thick, and secured by nails. The form of these battens may be varied according to taste: in fig. 143 a few are given. In well-con-

Fig. 141.

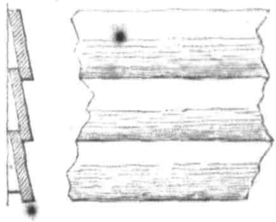
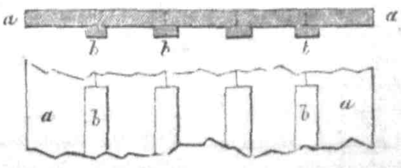


Fig. 142.



structed frame-houses, the interior facings are built up with brick, and plastered. Where this is objected to, the inner face of the posts may be rebated (see JOINERY), as in fig. 144, where *a a* is the post, with rebates as *b* on the inner face. Boarding, planed on the outer face—that is, to the side to be presented to the room—may be placed between the posts, going in at each end into the rebates of the posts, and there secured. If the thickness of the boarding is equal to the depth of rebate *b*, the face will be flush with that of the post *a a*. The paper or paint may be placed at once on the face of the boarding. The space between the inner face and the exterior weather-boarding, as at *d*, may be filled in with some non-conducting material. A method of making the exterior and interior finishings for walls of timber, almost universally adopted in Sweden, may be noticed here: *a a*, fig. 145, are the upright posts; *c c* a range of boarding laid horizontally: an outer range, *d d*, is placed above this vertically, secured by battens as in fig. 146; the inner boarding *b b* is horizontal. The space between the posts and boarding is filled with non-conducting material.

Fig. 143.

Fig. 144.

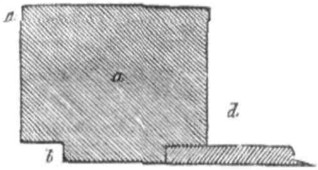
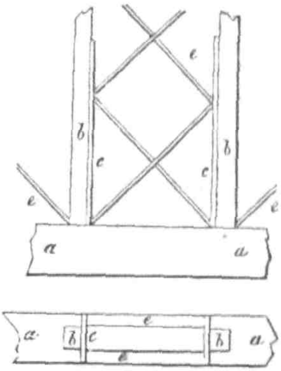


Fig. 145.

There is one decided objection to frame-houses—that is, their extreme liability to fire. We think that a method of combining the rapidity with which a house of this description may be built, its economy where wood is plentiful, its durability—and at the same time securing to it an almost absolute fire-proof condition—will be useful and acceptable. The method we have to propose is amazingly simple—it is an adaptation of a plan much used in Paris for making fire-proof partitions. The upright posts are to be placed in the horizontal foundation, at distances not greater than 2 feet; where window and door openings occur, they must necessarily be

placed wider apart. Let *a a*, fig. 146, be the foundation; *b b* two of the posts; to the inside of these nail firmly flat boards *c c*, 1 inch thick, and of the breadth of the intended thickness of wall. Provide struts *e e*, 2½ inches wide by 1 thick, and place them between the posts in the manner shown in the sketch, one at each side; secure them to the boarding *c c*. Having provided a hard-setting mortar, or mixture of gypsum and sand, or other easily-made cement (see CEMENTS), fasten a board, of dimensions sufficient to cover one at least of the large diamond-formed openings, temporarily, yet firmly, either to the outside or inside of the posts; next procure a number of pieces of broken and angular stones of all sizes, not exceeding, however, that which could pass through a ring 3 inches diameter; place these within the interstices formed by the struts *e e*, placing them as carefully as possible, so as to be flush, or nearly so, with the outside and inside face of posts. Having thus well fitted the spaces, proceed to press well in, from the side opposite to that on which the flat board is temporarily fastened, the thin mortar or cement—taking care that it shall thoroughly permeate through the interstices of the stones packed up between the timbers. Having thus carefully filled in one portion with the stones and cement, remove the flat board to another portion, and proceed as before. The rough places afforded on each side of the wall by the projecting portions of small stones, will afford an excellent hold for the outside finishing and interior plastering. The roof can be made in exactly the same way, care being taken to place the flat boards on the under side of the timber, and allowing the cement a longer time to set. A house made on this principle will be dry, economical, quickly constructed, and almost absolutely fire-proof.—(For methods of forming partitions to log and frame houses see CARPENTRY.) We have now to describe another method of constructing the exterior walls of houses.

Fig. 146.



SECTION THIRTEENTH.

PISÉ, OR HARD-RAMMED EARTH.

Taking into consideration the ease with which the material is obtained, worked into its requisite form, and the durability which undoubtedly characterises it, we are certainly surprised that it should have been so sparingly adopted. No valid objections have yet been raised against it. It is admitted by all to be cheap, and no less efficient than cheap. Numerous examples have been carried into effect with marked success, and abundant evidence is easily obtained to prove that it is lasting.

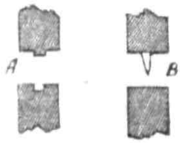
The term "pisé" is derived from the name of the instrument with which the earth is rammed down, *pisoir*. The kind of earth or soil best adapted for pisé is that known as gravelly. By this term is meant a soil in which the pebbles or stones are round, not flat or angular. It is evident that in ramming the soil the packing will lie equally round the circular pebbles, while the flat or angular ones may resist the stroke of the rammer, and ward off in a measure the force of the stroke from some portion of the soil beneath them. Brick earths are well adapted for pisé; but, owing to the capacity for retaining moisture, they are apt to crack, unless carefully shielded from the wet, during the process of drying the walls. All kinds of earth, however, may be used, with the exception of light poor lands, and strong clays: these, however, will do if judiciously mixed with other better-fitted soil. To show how this mixing may be most successfully carried out, a few sentences may be useful: the principle of mixing is simply to blend a light earth with a strong, a clayey with a sandy or gravelly kind. Where the best kind of soil that is gravelly cannot be obtained, small round pebbles, &c., may be mixed with it. All animal or vegetable substances that are apt

soon to decay must be carefully kept out of the soil to be used. The following indications, which may be observed in order to judge of the fitness of the soil for pisé in any district, may be useful: In digging, if the spade brings up large lumps at a time, the soil is well adapted for the work; this holds also where the soil lies on arable land in large clods, and binds after a heavy shower and a hot sun. Where vermin-holes are smooth in the inside and firm, or where the small lumps generally found in plenty in all fields are difficult to be crumbled between the fingers, the soil is good. Soil of good quality is generally found at the bottom of slopes that are in cultivation, and on the banks of rivers. In preparing the earth for building, the first operation is breaking the clods or lumps, and thereafter placing the soil in a conical heap: this form facilitates the removal of large, flat, and circular stones, which, falling to the bottom, are easily removed from the mass by means of a rake. The teeth of the rake should be placed at intervals of 1 inch or thereabouts, so that only stones exceeding this in size may be withdrawn; or what would be better and quicker, a bricklayer's sieve or "screen" might be used, having the meshes about an inch square. Where two varieties of soil are to be mixed, the operation should be done at this stage. Enough of soil should only be prepared to last a day's working. Care must be taken to prevent rain saturating the earth with water, as in this state it will form mere mud in the mould. It is necessary to note that the soil is in best condition for working when neither too dry nor too wet. It is very evident that less time will be lost in slightly wetting the soil, when too dry, than in waiting for it to dry should it get saturated with rain by a careless exposure.

The next point we have to explain is the construction of the "mould." This should be made of clean thin planks of pine, or other light wood, well seasoned, to lessen the chances of their warping. Their thickness should be about 1 inch, well planed on both sides. The length should be from 12 to 14 feet for ordinary work; but shorter moulds, as 7 feet, will be at times useful. The depth of the mould should be 14 inches—some recommend 2 feet 9; but a practical experiment, where the former depth was adopted, showed that it was more convenient than the latter, giving at the

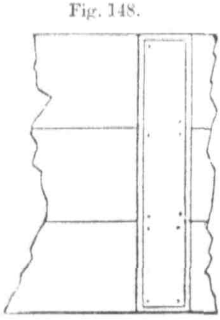
same time greater facilities for detecting error in carrying up the walls. The two sides of the mould, of whatever depth, are formed by the requisite number of planks laid edge to edge, and tongued and grooved as in fig. 147 at *A*, or held together by pins as at B, placed at a distance of from 4 to 6 inches. Battens, as in fig. 148, should be nailed on the outside of the side of the frame, at intervals of 30 inches, or thereabouts. Iron handles may be placed at each end of the upper edge of frame, to facilitate its removal.

Fig. 147.



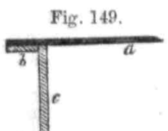
It is necessary to have the boards forming the side of frame, and the battens, of one uniform thickness. In forming the angles, a separate frame is required; this should be of same depth as the other, but having battens at each end only, and these in the inside. These should be put firmly on with screw-nails, as the ordinary ones are apt to start. The use of these battens is to prevent the head of the mould from springing out when forming the ends of the wall.

Fig. 148.



The pressure being outwards, the head of the mould must evidently be of the same depth as the mould, and its width equal to the intended width of wall. This is shown in fig. 149, where *a a* are the sides of the mould, *b b* the inside battens, *c* the head. The next point to be attended to is the "joists." These are to be made of hard timber, 4 inches broad and 2½ deep. Suppose the thickness of the wall to be 14 inches, the sides of the mould or frame being each 1 inch thick, mortises must be cut at each end of the joist, as in fig. 151, the distance between the inner ends of which must be 16 inches. This will give a width between the inside faces of the mould of 14 inches, equal to the intended thickness of wall. Fig. 150 shows the plan of the joists and sides of the mould when laid on the wall. The mortises should be 1½ inch wide, and some 4 or 5 long;

Fig. 149.



and in order still further to facilitate the placing of the sides of the mould, grooves *a a a a*, fig. 151, some $\frac{1}{2}$ inch deep, and 1 inch wide (the thickness of the sides), may be made in

Fig. 150.

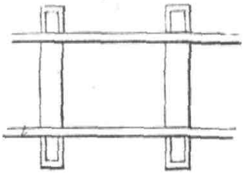
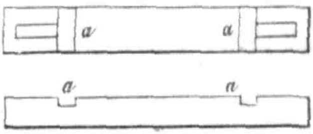


Fig. 151.



the upper sides of the joists, close up to one end of the mortise. "Posts" are next to be provided, 4 inches square, and equal in length to about twice the depth of mould. Tenons will be made at one end to fit into the mortise in the joists. The outer sides of the mould will thus press closely against the inside face of each post. It is essentially requisite that all the posts shall be of uniform scantling, and the tenons all of the same size: this will prevent numbering being necessary, and facilitate operations. The foot of the posts *a a*, showing tenons *b b*, is shown in fig. 152. "Caps" are next to be described. These consist of pieces of hard wood *a a*, fig. 153, 4 inches broad, and $2\frac{1}{2}$ or 3 inches thick, having snugs *b b* same breadth, and $2\frac{1}{2}$ inches thick, dovetailed at each end. The distance in the inside of these snugs should be 25 inches, so that space may be afforded on each side to drive thin wedges between the inside face of snugs and outside face of posts. The method of using the apparatus may now be briefly described. The foundation of the building to be erected is to be of stone or brick, at least 18 inches above the level of ground. The joists, figs. 150, 151, are next to be laid on the wall, at distances corresponding to the

Fig. 152.

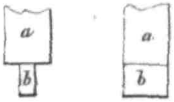
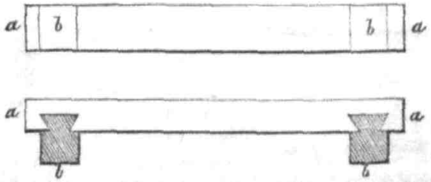
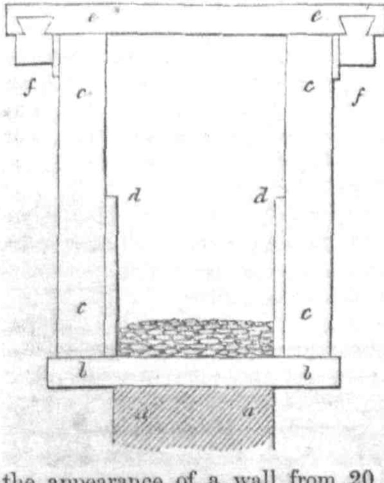


Fig. 153.



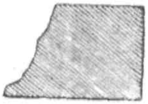
length of boards forming the sides of mould. The joists should be so laid that the inside and outside line of foundation-wall shall correspond with the inside line of mortises cut in joists, fig. 150. Having adjusted the joists, the foundation-wall, in stone or brick, must be increased in height a course or two, so as to enclose the joists in the body of the wall. The posts with tenoned ends are next to be inserted in the mortises of the joists, the sides of the mould placed in the grooves, the outside end filled in with the prepared board, and the caps finally adjusted over the upper ends of posts, and driven hard up by means of the wedges. The mould sides will, by this means, be able to resist the force of compression used in ramming the earth; while the end nearest the extremity of wall will be prevented from flying out by means of the battens placed at the ends of each side forming the mould, as before described. In fig. 154 the arrangement of the various parts may be seen: *a a* is the brick or stone wall, *b b* the joists, *c c* the posts, *d d* sides of mould, *e e* cap, *f f* the wedges to drive up the same. It should be here noted, that, as the foundation in stone or brick is worked round, the joists used at one part of the building should be driven out (to facilitate their removal, they are made slightly narrower at one end than at the other), and placed as before: thus, when the foundation is finished, it will present the appearance of a wall from 20 to 24 inches high, having all round it square or oblong holes, in which the joists can be placed. Before commencing to ram the earth in the mould, it will be necessary to try it by means of the plumb-line and square, to ascertain that it is properly levelled. The operations must be commenced at one angle of the wall,

Fig. 154.



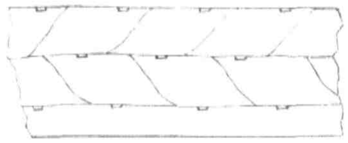
the head of the mould being at the outer extremity of wall, within 14 inches of it, the joints being at that distance from the outer extremity in consequence of the thickness of return-wall. The labourers appointed to prepare the mould, hand it up to those engaged in ramming it in; these take the earth and lay it out at the bottom of the mould to the depth of 3 or 4 inches: *more than this depth should not be put in at one time.* The first strokes of the rammer should be made close to the edges of the mould, thereafter going over the whole surface in regular succession, from the head of the mould downwards; thereafter crossing these first blows or indents by another succession. Care should be taken to give to each layer as equal a compactness as possible, which is easily attainable: *the parts under the caps must be carefully looked to*, as, from their position, the rammer must be used obliquely. The mould being thus filled by successive layers, each equally well rammed, the wedges holding the caps must be withdrawn, the caps taken off, the sides thus released taken out, and the joists finally drawn out of their holes in the wall, which should be filled up by proper means. In filling up the mould, the inner end should *not* be filled up to the same height as the other parts, but should be made to slope gradually down. This is shown in fig. 155. The joists are next to be placed in the adjoining holes, the sides of the moulds being *without* battens at the ends—these not being required, as no end to the mould is needed. The outer end of the sides should be so adjusted that they are on a line with the top of the slope of the first course of rammed earth. By this means, when the earth is filled in to the second mould, one end of it will lie upon the sloping end of the first course, thus forming a species of bond. The foundation-wall being, by a succession of moulds, covered with a wall of rammed earth, the height being equal to the depth of the mould, holes or slits are cut in the upper surface in which to lay the joists. These being prepared, the mould is to be set up as before at an angle of the wall, the sides having the battens at one end against which to fix the end; but the operation is to be begun at the opposite end of the wall to that originally started with. By this means, as each end of the mould is left sloping off as

Fig. 155.



before, the sloped surfaces in the second course will lie the *contrary way* to those in the first: the bond between the several courses will thus be increased in efficiency. It should be borne in mind that the holes for the joists, cut in the upper surfaces of the successive layers, should be so placed as not to be exactly above one another in all the courses, but each succeeding series between those of the series below. These recommendations will be seen exemplified in fig. 156. The gables of a house can easily be made by making the successive layers each shorter than the one immediately below it: the requisite slope will thus be obtained. When a day's work is finished, the wall should be covered with boarding, so that it may be covered in the event of rain; and the roof should be placed as soon after the walls are completed as possible. The roof should overhang at least 12 inches, to protect the vertical walls from the effect of rain. Where the building consists of two stories, the walls of the upper story may be made thinner than the lower, by setting at the level of first floor a depth of two or more inches from the inside, the outside being flush with the outside of lower wall. The rammer may be made of hard wood or cast iron; if of the latter material, its weight may be 14 lb. or thereabouts. Bond timbers may be used with advantage in pisé walls; they should be of the length of the mould, and in breadth equal to one-third the thickness of wall. As they are completely imbedded in the earth, they last for a great length of time. If considered necessary or more economical, the inside faces of the bond timbers may be made to lie flush with the inside wall of house. In this case they will serve as battens in which to drive nails or holdfasts for many convenient purposes. The openings for doors and windows should be left a little less than required; they may be dressed after the building is finished to the proper dimensions. Wood bricks should be built in here and there, to which to fasten the dressings and frames. The openings are made by placing heads, or a head, in the mould at the place where the wall is to terminate and the opening begin.

Fig. 156.



SECTION FOURTEENTH.

UNBURNT BRICKS.

Much as many may dispute the fact, it is nevertheless true, that unburnt bricks form a much drier wall than ordinary burnt bricks, inasmuch as they are not so absorbent of wet or damp. To make these, any ordinary clay will answer. If dry when obtained, it must first be moistened, and thoroughly worked by the feet of cattle, or pounded by hand. Cut some straw into pieces about 6 inches in length. After being duly mixed with the straw, the clay is ready to be made into bricks. A mould of any size must be made; a convenient size is 12 inches long, 6 inches wide, and 5 inches deep : this mould should have a bottom, but not air-tight, in order to prevent the brick from sticking in the mould. The clay is put into this mould, and the brick formed much in the same way as ordinary bricks. Should the clay be very tenacious, a little sand sprinkled in the mould will enable the brick to leave it freely. The bricks are placed upon level ground to dry, turning them on their edges on the second day; thereafter left in piles, protected from the rain, for ten or twelve days. The foundation must be formed of stone or burnt brick; and, to prevent damp rising, a course of slates should be laid above the footings in hydraulic cement. The walls formed of these bricks will be exactly 12 inches in thickness—that is, the length of the mould; the partitions are formed by laying the bricks lengthwise, thus giving a thickness of 6 inches, the breadth of the mould. To obtain the necessary bond in the walls, the work is carried up in alternate courses of headers and stretchers——one course having the bricks laid across the wall, the next course having them side by side. A good ordinary brick-mortar is to be preferred, although a weak mortar of lime and sand will do for laying the bricks. The doors and window-

frames should be previously made, to be ready to insert when required. These frames should be of stout plank, the exact width of the thickness of walls—they will thus help to cover the joints and strengthen the walls. Lintels and sills of stone, when easily had, will much improve the appearance of the structure: pieces of timber 3 inches thick, width equal to thickness of walls, may be used in place of stone; these should have a clear bearing of at least 12 inches on each side of the opening. Of whatever kind the roof is, it is essential, in this form of material for external walls, that it should be an overhanging one, in order to guard the walls from vertical rains. The outside of the walls is plastered with good lime-mortar mixed with hair, and then with a second coat pebble-dashed as in roughcast. The inside walls are finished in the usual way. A cottage may be built in this way for an incredibly small sum—warm, dry, and of course comfortable. As to its durability, it is only necessary to state, that it is by no means a difficult matter to adduce instances where such structures have existed in thorough efficiency for a great length of time; in some, for upwards of two hundred years. The method of forming the unburnt bricks will be described under the head of Brickmaking.

SECTION FIFTEENTH.

BRICK-SETTING.

Bricks are set in two kinds of ways, each securing a particular kind of "bond." These are "Flemish bond," and "English," or "old English bond." The term "bond" is used to denote the method of superposing bricks, so that the joints of any one course are placed opposite the solid part of the bricks forming the course either above or below it: this is termed "breaking joint." Bricks placed so that their length corresponds with the line of wall, are called "stretchers;" those placed at right angles to the line of wall are termed "headers:" thus *a* in figs. 157 and 158 is a stretcher, *b* a header. Each row of brickwork thus formed is termed a "course," the regular thickness of a brick being 3 inches; each course is thus confined to the same height.

Fig. 157.

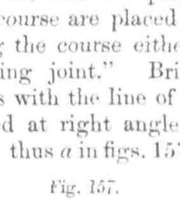
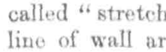
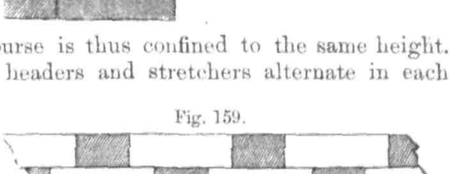


Fig. 158.



In Flemish bond, headers and stretchers alternate in each course, the headers of one row resting on the stretcher below. Thus in fig. 159 the plain parts are the stretchers, and the crossed parts the headers.

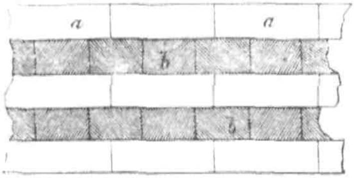
Fig. 159.



English bond consists of one row of stretchers and one row of headers, in alternate rows. Thus in fig. 160, *a a* are the

stretchers, and the crossed parts *b b* the headers. Flemish bond is reckoned to be neater in appearance, from the manner in which the joints are disposed; but in consequence of there being a predominance of stretchers over headers, the lateral tie throughout the wall or bond is weaker than in English bond. Old English bond, as it is sometimes termed, being therefore the strongest, we would recommend its adoption in all cases. Brick walls are apt, if carelessly constructed, to "give" in two ways—splitting across the breadth, or transversely: this the stretchers are calculated to prevent. Secondly, splitting laterally, or along the length of the wall; this the headers are used to prevent. Of the two evils the latter is the worst, and should if possible be avoided. As a means of securing this, English bond is to be recommended from frequency of the headers. Where walls are built of a single brick, bond is obtained by making the bricks break joint.

Fig. 160.



The method of building brick walls hollow, now demanding such widespread attention, is possessed of many advantages, two of these being more prominently noticeable—the saving of material and the prevention of damp. The last is even of more importance than the first. Two other important advantages obtainable by the use of hollow walls are—the saving of lathing and preparation for plaster, the plaster being at once laid immediately on the inner face of the wall. We purpose to illustrate one or two plans of building hollow brick-walls. The first we shall notice is that known as Dearn's, which forms a 9-inch hollow wall. The lower courses up to floor-level are laid in ordinary English bond. The next course immediately above is formed by laying a series of stretchers on edge, thus leaving a space of 3 inches, as in fig. 161, which extends throughout the length of the wall. The next course is a row of headers laid flat, and so on. The sketch in fig. 161 shows elevation and section.

The 11-inch hollow brick-wall introduced by Mr Loudon,

and shown in fig. 162, is well adapted for cottage work: the projections left in the inside serve admirably to receive and retain the plaster. These 11-inch walls are formed by placing the headers 2 inches within the line of the stretchers, thus leaving a hollow space of 2 inches in the centre of the wall. If one or two of the interstices at the top and bottom of the wall be here and there filled up with cement, so as to afford a hold for nails by which to secure vertical butts, it is obvious that, by fastening paper or canvass immediately upon these, spaces will be formed in the inside of the wall as well as in the centre—thus adding another means for the prevention of damp. A 14-inch hollow wall may be constructed by placing two stretchers and a header on both sides of the wall, as in fig. 163, each row breaking joint with the other. By using Dearn's 9-inch hollow wall, shown in fig. 161, a saving of one-third in bricks is effected. But the saving in mortar is also considerable, as may be seen by inspection of fig. 164, which is a plan of the sectional elevation of fig. 161. The mortar is only laid beneath the ends of the headers in the

Fig. 161.

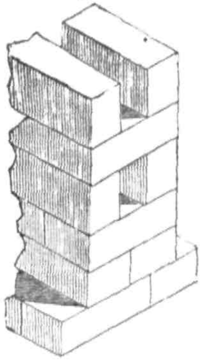
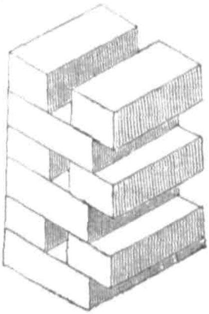


Fig. 162.



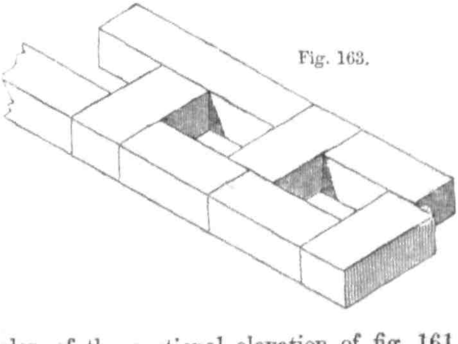


Fig. 163.

course above the stretchers on edge. Although the principal hollow is only in every second course, still this form may be said to be hollow throughout, inasmuch as in the row of headers, a small space is left between each brick, at which no mortar is placed: these hollow spaces are indicated by the dark lines in fig. 164. There are numerous patent hollow bricks, which are fast coming into use; we have as yet only noticed the methods of obtaining the advantages of hollow walls by the use of the ordinary-shaped bricks—the bricks which are hollow in themselves requiring, for their making, machines more or less complicated, not easily obtainable by the majority of farmers even in this country, but totally beyond the reach of the emigrant settler in a new country. It may be well, however, to notice the principle of hollow bricks.

Fig. 164.

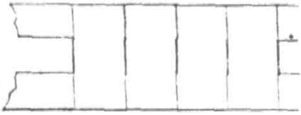


Fig. 165.

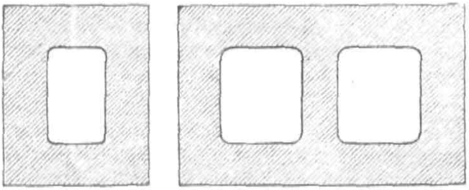
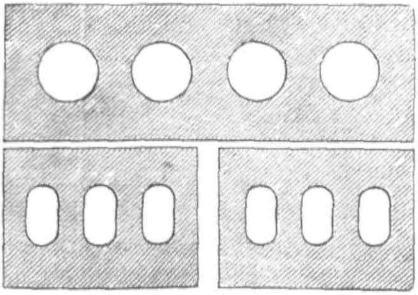
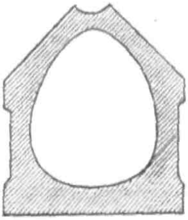


Fig. 166.



In place of forming the cavity in the wall by the disposition of ordinary bricks, as now illustrated, bricks hollow in themselves are used. In fig. 165 we give a section—one-fourth of the real size—of a form of hollow brick introduced into practice by the Scottish Labourers' Cottage Association already referred to. These bricks require no "headers," as the broad brick breaks bond over the narrow

Fig. 167.



one in every course. They are 15 inches in length. Fig. 166 illustrates a section of a perforated brick; and fig. 167 a section of a hollow brick for lining walls or forming partitions, both of which have also been introduced by the Association into practice. These are both drawn to a scale of 3 inches to the foot. For other forms of hollow bricks, see the Section on Fire-Proof Construction.

SECTION SIXTEENTH.

STONE WALLS—CONSTRUCTION.

STONE for building is used in three ways—"rubble," in which the blocks or pieces are used of all sizes, without being squared; "coursed work," in which the pieces are in some measure sorted into sizes of a uniform bulk, and these built in courses; "ashlar," in which the stones are squared off to certain required dimensions. The "bond" in stone-work is obtained by laying each course in such a way that its joints lie opposite the solid parts of the course below.

In building stone walls, the footings forming the foundations should consist of the largest stones which can be procured—that is, consistent with the proportion due to the intended thickness of wall. The best form to have them in is rectangular; if not square, the largest surface should be laid horizontally. Stones tapering downwards should not be used as footings without hammer-dressing; if tapering, or resting upon angular or irregular ridges, they are apt to sink and yield by the superincumbent pressure of the walls. If possible, the stones for the footings should be obtained of the full breadth. If a sufficient number of these cannot be obtained, the space between two of these may be filled up by stones of less dimensions, disposed like the stretchers in a brick wall. If stones sufficiently large, as above noted, cannot be obtained, then care must be taken to arrange the various pieces with relation to each other, that they may break joints. In well and strongly built walls, bond timbers will not be required: in fact, where they can at all be dispensed with, it is better to do so. Stone walls may be made hollow, by using two planks of any desired length, these being kept separate, and parallel to each other, by means of screws—the distance between the planks corresponding to

the width of hollow required. The planks being set in the centre of the wall, the courses of ashlar or rubble are built up on each side to the upper side of the planks; the screws are then slackened, and the boards, being thus released, can be placed so as to form another course. The planks should not be longer than 3 feet; and at each end bond pieces or headers should be laid across, thus binding the two sides together. The advantages of a hollow stone wall may also be easily obtained by building a single thickness of brick, built up and connected with the stone wall while constructing the latter. In all cases where the soil is damp, the foundation should not only be well drained, but the hydraulic mortar should be used to lay the foundation courses. We may here append a few general notes on Construction, which may be useful to the reader.

In all cases, whatever material be used for the construction of walls, it is essential that the excavated areas beneath flooring, &c., should be well ventilated: this may be effected by leaving apertures in the wall, just above the ground-line. On all sides of the house this allows a current of air to circulate beneath the joists, and removes all rising moisture.

In carrying up brickwork, the walls should be kept of as uniform a height as possible, no particular part being carried up more than 4 feet at a time: this is necessary, in order to prevent cracks in the structure, since all walls, immediately after building, shrink: the part which is first carried up will remain stationary, while the adjoining part, being brought up to the same height, will settle or shrink, and thus leave the other part, forming a crack; hence the necessity, where good work is required, of carrying up the courses as uniformly as possible. In carrying up any part, the beds should be sloped off, so as to bond well with the adjoining portions. To prevent still further all irregular settlement in brick walls, "bond timbers" are sometimes used; these are pieces of timber of the thickness of a brick, and are built into the wall. A practice among builders too generally adopted must be noticed here for condemnation—this is, building the ends of joists into the walls, as in fig. 168, where *a a* is the wall, *b b* the joists. This is apt to cause the walls to settle, in consequence of the shrinking of the timber. This is more especially to be avoided in placing the ground-floor joists, as,

the nearer to the foundation, the greater liability to damp, and consequently speedy decay of the timbers. The joists of basements should be supported on small piers *a*, carried up from the foundation *b b*, as in fig. 169; and in cases of upper-

Fig. 168.

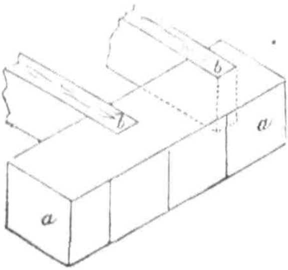
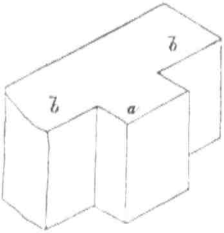
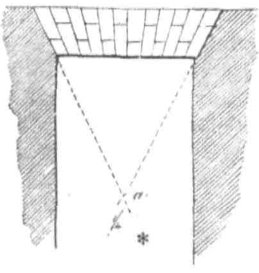


Fig. 169.



floor joists, they should be placed in recesses purposely built for their reception in the thickness of the wall, so that the strength of the wall may be quite independent of them, or notched on to the wall-plates. In the majority of cases, however, it may be presumed that the requisite degree of soundness in construction may be obtained by the use of strong and sound timber lintels, care being taken that they have a good bearing at each end—in no case less than 12 inches. The size for openings of doors and windows of ordinary dimensions is 5 by 4 inches, with a bearing of at least 14 inches on wall at each end beyond width of same. To insure sound construction, and prevent settling, a flat arch, as in fig. 170, may be turned over the lintel: in this form the bricks should be wedge-shaped, and all converge to the same point *a*. In this form of arch, built with parallel-sided bricks, its whole strength is dependent on the mortar. A segmental arch is shown in fig. 171.—(For simple forms of

Fig. 170.

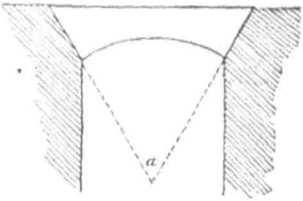


*

* *The fractional figures below the diagrams, in some instances, denote the* scale to which they are drawn. Thus $\frac{1}{8}$ means scale "$\frac{1}{8}$ of an inch to the foot," and so on.

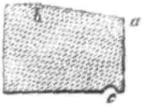
centring for arches, see CARPENTRY.) In building a brick house of more than one story, we would recommend the walls, up to level of bedroom floor, to be made at least 14 inches thick; and a "set off," from the inside of level of bedroom floor, of 5 inches, thus making the thickness of upper wall 9 inches: this set-off will make sufficient space to lay the "wall-plates" on which to notch the flooring-joists. Brick-work is built up with the aid of scaffolding. This consists of stout high poles, fastened firmly into the ground, about 5 feet from the face; horizontal pieces are lashed at each end to the upright standards, parallel to the wall: on these one end of the "putlogs" rests, the other is built into the wall. The putlogs are about 6 feet long. On the putlogs, the boards forming the scaffold, on which the men work, are placed. After the putlogs are withdrawn, the holes left by them should be filled up. The tools used for simple brick-constructions are, the "trowel," with which to spread the mortar and make the joints; the "brick-axe," by which the bricks are broken or cut into any desired angle, the parts broken being smoothed by rubbing them on a stone before placing; and a flat square-edged "rule" is used for pointing and running the joints—that is, making them fair and parallel on the outside face of work. The "square," "plumb-line" (hereafter illustrated), and "spirit-level" are used to keep the walls vertical and level.

Fig. 171.



Where lintels are formed of stone, the bearing should not exceed 6 feet. In making window-sills of stone, their upper surface should be bevelled off towards the front, as at *a b*, fig. 172. This allows the rain to run easily off; but as it would be apt to pass under the lower edge, and thus reach the wall, it should be "throated," as at *c*—that is, a part hollowed out; this prevents the "drip" from reaching the wall. This precaution should be adopted in all instances where a projection is made from a wall, on the upper side of which rain is suffered to fall. We do not think it necessary to give directions as to the dressing of stone,

Fig. 172.



as, for the purposes of the emigrant, rubble or hammer-dressed stone will answer all purposes. When he can afford to have an ashlar-fronted house, he may then be presumed to have the best assistance in all departments. A few notes as to the more simple operations may, however, be useful. The *tools* used are chisels, with the cutting edges of various sizes, the smallest being about $\frac{1}{4}$ inch broad up to 2 inches. A "mallet" is used for striking the chisels, shaped something as in fig. 173, with a short handle. In bringing a stone, say for a fire hearthstone, or the tread of a step, to a flat surface, two chisel-draughts are made at one side, and the end of the stone, somewhat like what is termed in joinery a rebate. These rebates are made perfectly flat, which is tested by placing a straight edge. Every part of the stone should coincide with the under side of straight edge. A diagonal chisel-draught is then made, connecting the ends of the side and end draughts previously made; another diagonal draught is made, crossing the first diagonal, and meeting the angle of the end and side draughts. All these being made as near as possible of the same depth, on the spaces between the draughts being blocked out, a comparatively flat surface is obtained. This is brought as flat as required by the use of the square; or the level of the surface may be tested by using two straight-edges of equal depth, thus: place one along an edge or arris of the stone, and on the opposite one the other straight-edge; by looking over the upper edge of the one straight-edge, if the upper edge of the other coincides, the surface is level.

Fig. 173.

Masonry is built with the aid of scaffolding, supported by two sets of standards, the system of putlogs not being admissible as in brickwork. A few notes on the method of laying rubble-work will be useful. In uncoursed rubble—that is, where the stones are of all sizes—some of the more prominent angles may be taken off with the hammer. The great art in this species of masonry is to dispose of the stones in such a manner that they will interweave, as it were, with each other, the mortar being well filled in between the interstices. In coursed rubble—that is, where the stones are roughly dressed to somewhat like a regular shape—the stones should be laid on their broadest surfaces, the interstices being well filled

with mortar, and the larger spaces between the stones being filled in with stones of a smaller size. In fig. 174 the mason and bricklayer's trowel is shown, 7 inches long in the blade *a*, 5 in the handle *c*, and $1\frac{1}{2}$ inch return at *b*. In fig. 175 the plumb-level is shown. This is used to ascertain whether any surface, as a course of brickwork or masonry, is level. It is laid on the surface as *b*: if it is level the plummet *f* hangs vertically down, the rope by which it is suspended from *d* coinciding with a line drawn from the

Fig. 174.

Fig. 175.

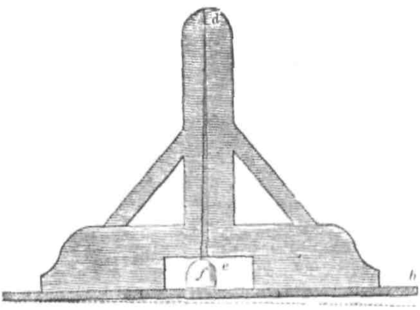
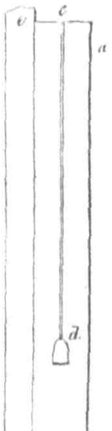


Fig. 176.



point of suspension exactly at right angles to the line of base, as *b*. The spirit-level is used for the same purpose as this instrument; it need not be here described: suffice it to say, that when laid on the wall, if level, the "air-bubble" will be exactly in the centre. The plumb-line for adjusting vertical heights, as posts, &c., is shown in fig. 176. It consists of a flat board *a b*, down the centre of which a plummet *d* hangs; the line drawn from *d* is at right angles to the end *b*, the sides being parallel to this line. Suppose it is required to test whether an upright post *e e* of a "frame-house" is vertical, the side of the plumb-line *b* is applied to the side of *e e*; if it is vertical, the line by which the plummet *d* is suspended will coincide with the line marked from *c*. An aperture should be made in the face of the board where the plummet hangs, the centre of which should be at the centre line, as from *e*, fig. 175.

SECTION SEVENTEENTH.

FIRE-PROOF CONSTRUCTION.

TAKING into consideration the obvious advantages arising from safe and economical house-construction, it is difficult to account for the apathy that so widely exists on the subject of rendering our dwelling-places less liable than they generally are to the ravages of fire. Doubtless, it may be said that the risk of loss from this source is so small—insurance-offices *charging only from one-and-a-half to two shillings per cent to cover it*—that it really is a matter of greater *economy* not to render buildings fire-proof; to run the risk, in fact, rather than go to any expense in obviating or lessening it. As the matter, then, with many, may come to be considered as one merely of comparative expense, we have some clue to the existence of the apathy to which we have above alluded as existing in connection with the subject,—an apathy, therefore, which, viewed in this light, is only apparent. This mode, however, of viewing the question of economy is a very narrow one, and by no means comprehends all its conditions. The building and its contents may be covered by insurance to the full amount; but the mere payment of this, in the event of fire, does not and cannot overbalance the attendant inconveniences—loss of time, health, and perhaps life—incurred by the accident; not taking into account the loss of many things which money cannot replace—the treasured heirlooms, the gifts of affection and of worth, or the records of high value, as well as the complete breaking up of many endearing associations which may be connected with the place. Looking at the matter from this important point of view, it seems scarcely too much to say, that all the means and appliances in our metropolitan dwelling-houses, and those of like construction and arrangement, by which *personal safety*

can be secured in cases of fire, are *nil:* at least, this is true so far as the adoption of well-devised and universally-adopted plans is concerned. As our dwelling-houses are generally *constructed, the chances of escape are hugely against the* inmates—of the upper portion, at least, of the building—when a fire takes place and is not speedily subdued. The very points to which attention should be paid—as partitions, roofs, ceilings, and, above all, staircases—are those not merely neglected, but actually constructed as if to increase the chances of fire—at least, to aid materially its extension and force.

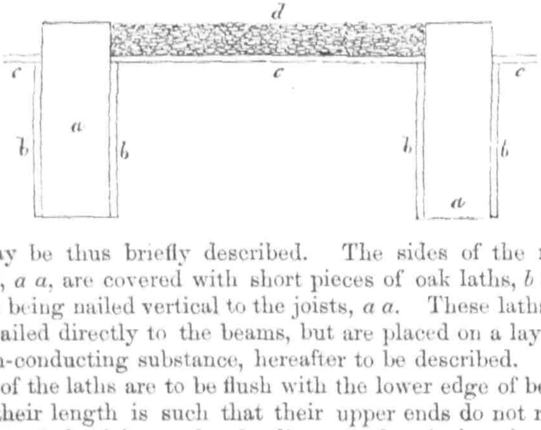
As a matter of economy, convenience, and safety, it seems to be worth while, therefore, to consider whether, by an additional small per-centage on the original cost of building, a comparative immunity from danger by fire can be obtained. It is the object of these few "notes," to detail as briefly as possible a few of the more simple and practicable plans which have been proposed for this purpose; adding, in this way, a small contribution which may be useful to the solution of the question under consideration.

History gives us little or no information as to whether this department of construction received any attention from the builders of the ancient or mediæval structures. The temples of Egypt, and of Greece and Rome, and the Gothic cathedrals of Europe, were all fire-proof, or nearly so, from the bulk of stone and the small amount of wood which was used in their erection. It seems only to have been in comparatively modern times that the necessity arose for having some plans by which to prevent fire and its wide extension. Wood, at one period of our history, was the principal, if not the only, material used for the erection of our *domestic* structures; and it was mainly owing to the too frequent recurrence of widely devastating fires, arising from the ease with which this material extended their ravages, that other and less perishable materials were used in construction. But the habit of using wood, and the prejudices in its favour from its cheapness and ease of working, were not so easily eradicated; and hence its use predominated too much, even in erections obviously built of other and more durable materials: and this superabundance of wood, to the rejection of better materials, is still a marked feature in modern—unfortunately we cannot call it scientific—house-construction. Although the chances of fire under the new

style of "mixed material" construction were much reduced, still the number of fires constituted by far too great an average not to be the subject of considerable attention. Hence arose many plans which had for their object the rendering of houses comparatively fire-proof, in which the materials were of a mixed description.

Passing over the plans which may be considered more as experimental or speculative than practical, we come to consider that introduced by the celebrated Earl Stanhope, so well known by his various inventions, as the printing-press, &c. The principle adopted in this plan is illustrated by fig. 177. The earl gave it the term of "under-flooring," and

Fig. 177.



it may be thus briefly described. The sides of the main joists, *a a*, are covered with short pieces of oak laths, *b b b b*, these being nailed vertical to the joists, *a a*. These laths are not nailed directly to the beams, but are placed on a layer of a non-conducting substance, hereafter to be described. The ends of the laths are to be flush with the lower edge of beam; but their length is such that their upper ends do not reach the top of the joists under the distance of an inch and a half. On the ledges thus formed, horizontal laths, *c c c*, are placed, and form a sort of platform or floor between two contiguous joists, upon which the non-conducting substance, *d*, is placed.

The non-conducting substance alluded to is prepared as follows: Cut a quantity of hay into lengths of three inches, not shorter; mix three measures of this with one of common sand, and two of slaked lime; beat them well up, dragging the hay well through: the stiffer the rough mortar is, the better, provided it is not too stiff to be spread with facility. The plaster or non-conducting substance, laid as explained by

fig. 177, must be thoroughly dry before the flooring is laid. Should any cracks be found in the material after drying, they should be made good by applying a little "mortar wash," with a brush. This is made as follows: Mix two measures of quicklime and one of common sand with water, stirred up till of the consistency of jelly. This will dry in a few minutes after application. Before laying the flooring-boards, a little dry sand should be sprinkled on the surface of the non-conducting substance, not on the beams.

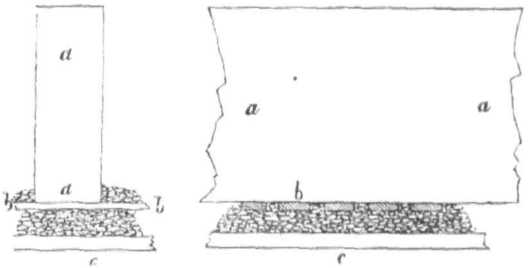
The Earl of Stanhope introduced a modification of this plan, which he termed "double under-flooring." The plan, as shown in fig. 177, is first carried out. On the lath flooring thus made, between the joists, a thin layer of "rough mortar" is placed, then a second layer of laths, the same length as the first layer—these being imbedded in the mortar while soft. A third layer of rough mortar is then placed on the laths, then a third layer of laths, until the last layer of mortar is flush with the upper surface of the beams. The non-conducting substance between the joists can thus be made of any desired thickness. Another feature of the plan is the "extra lathing." On the laths which are fixed to the sides of the joists, a thick layer of the mortar is placed; a second set of laths of same length as the first set is nailed thereto, care being taken to bed them well in the mortar. The second line of laths thus nailed should also be covered with mortar. We may here give a notice of an experiment which was conducted before the Lord Mayor of London shortly after the plan was introduced, in order to test practically the efficiency of the method. The system of double under-flooring and extra lathing was carried out in the experimental building. "The first experiment was to fill the lower room of the building, which room was 26 feet long by 16 wide, full of shavings and faggots, mixed with combustibles, and set them all on fire. The heat was so intense that the glass of the windows was melted like so much common sealing-wax, and ran down in drops; yet the flooring-boards of that very room were not burnt through, nor was one of the side-timbers, floor-joists, or ceiling-posts damaged in the slightest degree; and the persons who went immediately over the room filled with the fire did not perceive any ill effects from it whatever, the floor of the room being perfectly cool during the enormous conflagration imme-

diately underneath." Such, briefly described, is the Earl of Stanhope's plan: crude and unfinished in its details as it may appear, the germ of an efficient plan is contained within it. The principle of the non-conducting substance is that which is carried out in nearly all modern systems of fire-proof building. The plan is evidently capable of various and easily-adopted modifications.

Next in importance to the construction of floors is that of "ceilings." Possibly, a fire-proof floor may by some be considered as not so important a matter as a fire-proof ceiling. Certainly, as the natural course of fire is upwards, it seems of more moment to put obstacles in the way of this natural course rather than in that of the opposite: fire has comparatively little tendency to spread downwards. Ceilings, as almost universally constructed, are little or no protection to the joists above; very little heat from burning materials in the room below will soon cause the plaster to scale off, and expose the timbers: the further progress of the fire after this happens is only a matter of time, little chance remaining of its being stopped without extraneous aid. Could, however, a fire be confined to the room in which it originated, its burning itself out without damage to the neighbouring rooms would be a matter of comparative certainty, even where no means were adopted to extinguish it. To effect this grand desideratum, it will be necessary to have fire-proof ceiling, walls, and floor. How to make the latter we have already shown; we now proceed to explain the method of securing the former. By far the most efficient and simple plan we have yet met with is that adopted by the Parisian builders. Mr Hosking, in his admirable work, *Healthy Homes*, goes fully into the details of this system. To the reader anxious to go into what may be termed the "philosophy" of the subject, we cordially recommend a perusal of the work: we shall content ourselves by giving a very short, but, with the aid of an illustration, we hope a clear enough explanation of the system. Under the joists, as *a a a a*, fig. 178, a series of strong horizontal laths, *b b b*, are fastened securely. A space is left between each pair. A platform of any convenient dimensions is placed beneath the lathed surface, as *c c*, the distance between the laths and upper surface of the platform being about an inch. Mortar, having mixed with it a large quantity of plaster-of-Paris, is squeezed or forced into the space be-

tween the platform and the laths. The mortar passes between the spaces of the lathed surface, and, overlapping them on

Fig. 178.



the upper side, becomes, as it were, "keyed" in. The mortar being set, the platform is removed, and another portion proceeded with. When finished, the ceiling presents a smooth surface, the material being an incombustible, non-conducting substance, at least an inch thick, and, being well keyed to the strong laths above, not liable to scale off. The under or room side of the ceiling being left rough—to aid which the upper surface of the platform may be provided with longitudinal or cross ribs—the surface is in a proper condition to receive the finishing plaster.

Having shown how ceilings and floors can be made fire-proof, we now proceed to explain methods for securing fire-proof partitions.

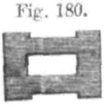
It is generally agreed that *a* most, if not *the* most prolific source of danger in houses, as generally constructed, is the plan of adopting "hollow quartering partitions." In the great majority of cases they may be said to act as channels by which the fire, breaking out in one apartment, is most speedily and certainly conveyed to the others. We can easily conceive of wood consuming more or less slowly within a chamber, without communicating with other apartments so long as the plaster remains intact, until measures can be carried out to reduce it. So soon, however, as the plaster scales off—a process generally a very speedy one, in the very flashy constructions of modern days—and exposes the lathwork below, the work of speedy communication of the fire commences. The spaces, in fact, act as chimneys, constructed unfortunately of

the materials best calculated to promote the danger. The following is the dictum of a first-rate authority on this point, one educed by long practical experience: "Any step, indeed, from the hollow quartering partition towards a solid wall, is a step towards security." To avoid the obvious disadvantages of solid partitions, hollow brick walls may be used, or a modification of the Parisian plan. This may be effected by placing strong pieces between the vertical framework, so as to form a species of net-work, as it were, between which masses of loose rubble stone, from 1 to 2 inches diameter, should be placed, the interstices between being filled up with plaster-of-Paris mortar, in the manner described when treating of the method of forming Parisian ceilings (see fig. 178): this would be almost absolutely fire-proof—(for description, see fig. 146.) *Partitions can, however, be most advantageously and* cheaply formed fire-proof by using hollow bricks. There have been a large number of different plans for this purpose introduced during the last few years. Roberts' patent hollow bricks are well known. Fig. 179 shows various forms adapted

Fig. 179.

for partitions: the sketch to the right is the form used for $4\frac{1}{2}$-inch partitions, of which fig. 180 is a sectional elevation.

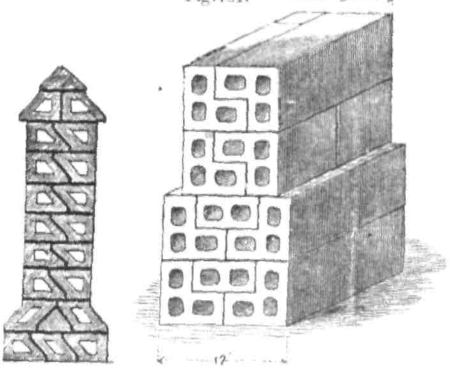
Fig. 180.



These bond with the splayed bricks, and answer for floor and roof arches where the span does not exceed 7 feet. The sketch in the centre is the form used for $5\frac{3}{4}$-inch partitions, also for roof and floor arches, where the span is from 7 to 10 feet. The sketch to the left is a form also used for partitions, with web to give extra strength, and to adapt them for using on edge in partitions $3\frac{3}{4}$ inches thick, to rise in 6-inch courses. Fig. 181, being sections of dwarf walls, will give an idea of the immunity from fire likely to be obtained by the use of these hollow bricks. Partitions built with them are not only nearly absolutely fire-proof, but they deaden sound, and are considerably lighter than solid brickwork. They afford also great facilities for the conveyance of bell-wires, &c.

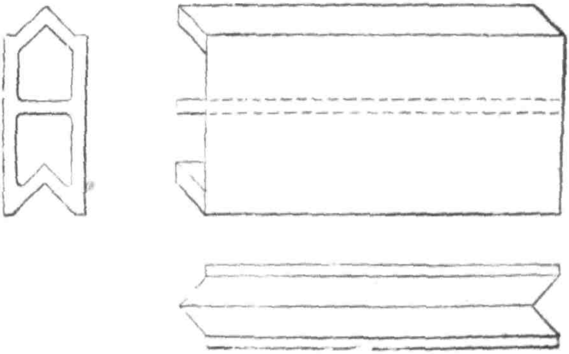
In fig. 182 we give a sketch of Hertslett's patent hollow brick, which we think admirably adapted for partitions, and seems deserving of a more extended use than apparently has been accorded to it. It is on the cellular principle, which gives it great strength in conjunction with lightness. The *stratum of* air which it contains will render it a bad conductor of heat

Fig. 181.



and sound; from the frequency of repetition of the joints, a good bond is secured, and little mortar, comparatively, will

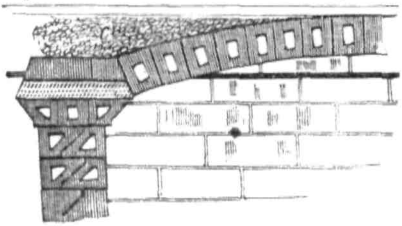
Fig. 182.



be required. Fig. 183 shows the application of Roberts' hollow bricks to the construction of fire-proof ceilings and floors. The external springers are of cast iron, connected by wrought-iron ties. The space above the arch, as at *c*, is filled in with concrete, and finished with a boarded floor *b b* resting on fillets.

Staircases, as generally constructed, are a prolific source of danger: composed entirely of wood, they are more frequently the cause of loss of life, from the ease and rapidity with which they are consumed, than a means of safety in affording egress to those situated in upper apartments: they, moreover, may be looked upon as leaders by which the fire is conveyed from one story to another.

Fig. 183.



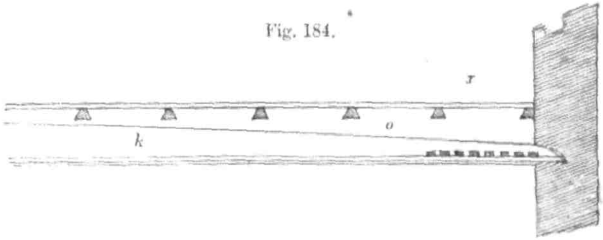
The Earl of Stanhope's plan was to secure the steps by his system of "under-flooring," already described. All attempts to set a staircase on fire, made on this principle, were unavailing. The Parisian method is an adaptation of the plan of forming partitions, already described. Batten laths are nailed at some inches apart on the under surface of the stairs, in the direction of its length. In this, triangular spaces are formed, one side by the longitudinal laths, the other by the face of the *riser*, and the third by the face of the *tread*. Into these triangular spaces loose rubble is placed, and the whole made to cohere, and form a solid mass, by mortar forced up from below, between the interstices of the laths.

To obviate the danger which arises from the generally-adopted system of staircases, Mr Gardner, of London, proposes the following, and which is recommended by the Board of Health: "The well to be carried up throughout with 9-inch walls. The doors opening on this at the several landings to be made of thin sheet-iron, with a space between 1½ inches in depth. These doors must be closed every night, so that in whatever apartment the fire may chance to arise, they would effectually confine it from the staircase, which, in almost all cases, *becomes a stimulant to its ravages*." Another suggestion, from the same source, is worthy of consideration. The trap-door leading to the roof is generally placed at the top of the well-hole; when this is open, the staircase becomes a vent or chimney, by which the virulence of the fire is much increased. By placing the trap-door in one of the attic rooms, the danger arising from this source is considerably lessened,

as the direct access to the trap from the staircase is thus cut off.

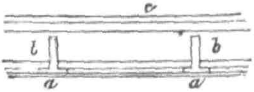
A method of rendering buildings fire-proof has been pretty extensively carried out, which is known as Fox and Barrett's patent. The principle is the substitution of joists, either of wrought or cast iron, for those of timber, and the employment of successive layers of incombustible materials, principally concrete. The joists are imbedded in these layers, the whole forming a solid fire-proof foundation. Upon this a finished surface of floor can be placed. The combination of the various materials, and their perfect consolidation into a compact mass, leads to the development of great strength and firmness, each material being so placed as to bring into operation its peculiar quality; the iron bearing the *tensile* strain, the concrete resisting the force of *compression*. In fig. 184 we give a longitu-

Fig. 184.



dinal section of a fire-proof floor on this principle: *k* is the iron joist, *o* the filling-in of concrete, in which the fillets are imbedded, in which to nail the flooring, *x*. A cross section of this is given in fig. 185, showing the joists *a a*, concrete *b b*, fillets and boarding *c c*. Ceilings on this plan require no laths.—The foregoing notes were contributed by the author to the *Building News*, in which they originally appeared.

Fig. 185.



Continental builders have long been celebrated for their fire-proof constructions. We give illustrations of one or two methods employed by them. In fig. 186, let *a a* be two light wrought-iron beams stretching across the floor, and resting on their extremities on the walls. Light iron rods, *c c*, are turned up at the ends, and rest upon the lower flanges of the beams *a a*. A separate view of the rod *c c* is shown at *d*. These

rods support the plaster of which the floor is composed—the upper surface of which is finished by light wooden battens, which rest upon the upper flanges of the beams *a a*. To these battens the flooring-planks are secured. Another method is shown in fig. 186. The rods *a′ b′*, which support the plaster,

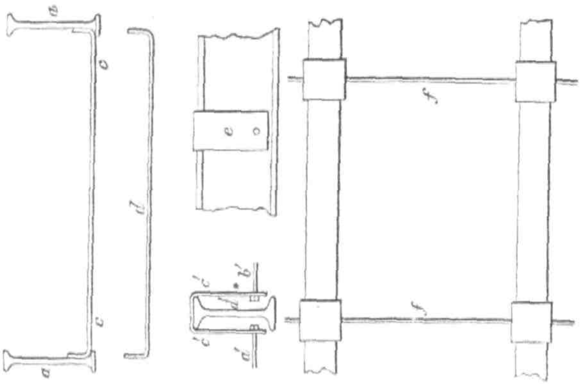
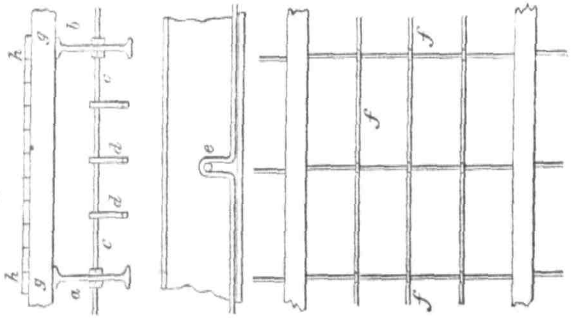


Fig. 186.

are secured to the saddle *c′ c′*, of wrought iron, which is placed across the wrought-iron beam *d′*; *e* is a side view, and *f f* a plan. In fig. 187 we illustrate another plan: *a b* are two of the



Fg. 187.

wrought-iron beams; *c c* are iron rods secured to the ribs of these beams. These rods support other rods, *d d*, which run parallel to the beams *a b*. The rods *d d* are bent in the middle, and passed over the rods *c c*, as shown in the side view at *e*; the arrangement of the rods is shown in plan at *f f f*, *g g* flooring joists, *h h* flooring planks.

SECTION EIGHTEENTH.

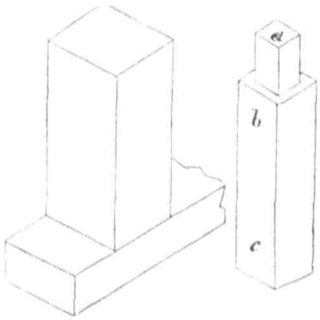
THEORY OF CARPENTRY.

Carpentry may be defined as the art of arranging timber used in various constructions, so as to be able to bear certain weights or to resist certain pressures. Carpentry, as a science, involves a thorough acquaintance with geometrical construction, and of the sections of solids and their coverings, the strength of materials, and of the actual amount of pressure or strain which can be safely laid on them, and a knowledge of those laws of mechanics having reference to the manner in which strains are continued or spread through a system of framing, and to the proportioning of the resistance of parts, so as to bear the various strains to which they are subjected: this may be termed the *theory* of carpentry. The *practice* may be defined as the method of arranging the joints and connections of the timbers, securing, as far as obtainable by good construction, the advantages of the arrangements of the framing derived from sound theory. In this section we purpose giving a series of papers on the theory of carpentry, containing an exposition of the mechanical laws already alluded to. Much of the practice will be explained and illustrated in a succeeding Section.

In arranging "frame-work," the first point to be attended to is to ascertain the direction, with the amount of pressure, which each portion of the assemblage of beams is subjected to—the great object aimed at being to obtain as much strength with as little outlay of material as possible; for it is to be noted that any unnecessary weight of material is not only a loss, but it acts prejudicially upon the points of supports.

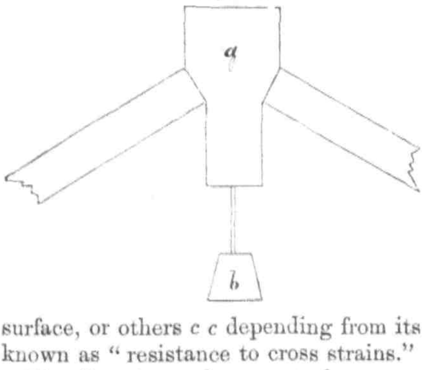
The strains to which timbers are exposed in the construction of roofs, &c., are three in number: 1st, compression; 2d, tension; 3d, cross strain. Where the timber, as in fig. 188, is compressed in the direction of its length by a weight *a*, resting on its upper end, or from the weight of the part above, as *b*, pressing on the lower part at *c*, the strength of the beam is said to be its "resistance to compression." Where the timber presses with the end of its grain on the side of the grain of another beam, the lower beam is subjected to compression: in this case the load or weight should never exceed a certain amount per square inch.

Fig. 188.



Where the beam is pulled in the direction of its length, as the king-post *a* in fig. 189, as by the weight *b*, the strength of the beam is proportional to its capability of standing the resistance to "tension." Where the beam is strained by a force tending to break it across, as a beam *a a* in fig. 190, resting on the walls *b b*, at its extremities, having weights *c c c* pressing on its upper surface, or others *c c* depending from its lower, its strength is known as "resistance to cross strains."

Fig. 189.



The direction and amount of pressure to which beams are exposed are ascertained by means of what is known as the "parallelogram of forces," or the "composition and resolution of forces"—which may be thus defined and illustrated: If a

body, as the weight *a* in fig. 191 A, be subjected to a pressure in two directions, as *b a*, *c a*, their force being in proportion to the length of the lines, the weight *a* is influenced just as if it were pressed in the direction of the line *d a*, which represents the diagonal of a parallelogram, of which *b d* is parallel and equal to *a c*, and *d c* to *a b*. How this proposition of mechanics is made useful in Carpentry we now proceed to show. In fig. 188, the weight *a* presses in a vertical direction upon

Fig. 190.

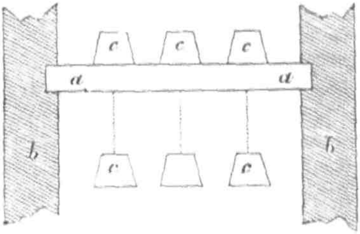
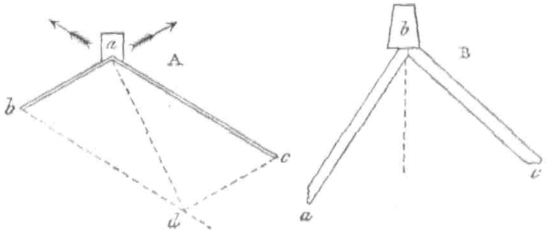


Fig. 191.



the block *b c*, the pressure being equal to the weight. But if the weight is supported by two beams or blocks, placed in an inclined direction, as *a b*, *b c*, fig. 191 B, the amount of pressure sustained by the two beams will not be equal to the weight, but much greater according as the inclination of the two beams is greater or less; neither will the beams support an equal proportion of the weight, but the amount sustained by each will be according to the angle or inclination which it answers with reference to the "resultant" of the parallelogram. It is thus that a small weight may be made to exercise a very great pressure by the inclination of the beams which support it; and hence the necessity of ascertaining the exact amount which each part of the framing is to support.

Let *a b*, *a c*, fig. 192, be two inclined beams, which are sub-

jected to a pressure of say 10 tons acting in the direction of the arrow, that is, if left free to pull the weight, would do so in the direction of *a d*. From any scale of equal parts, make *a d* equal to ten (the weight of the pressure in tons). From *d*, parallel to *a b*, draw *d e*, and, parallel to *a c*, *d f*. From the same scale of equal parts as *a d* was measured from, take the distance *a f*, or *a e*, and this—which in the example will be found to be equal to six—will give the amount of the pressure which the beams *a b* and *a c* sustain. As the inclination of the beams in this case is equal, the pressure is sustained by each in equal proportions. Thus in this case the amount of pressure, which, in the case of an upright beam, would be 10 tons, is increased—in consequence of the inclination of the two beams which are employed to support—to 12 tons. The increase of pressure by the increase of inclination is shown by the working diagram, fig. 193 A, where the weight is equal (10 tons) to that in

Fig. 192.

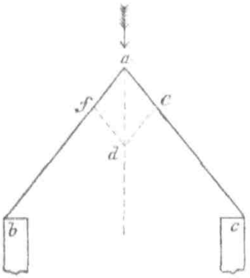


Fig. 193.

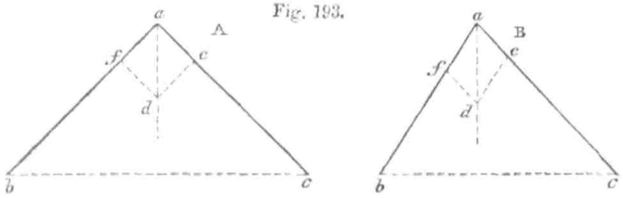


fig. 192, the rise or height the same, but the "span" or distance between the extremities of the beams, as *b c*, is increased to 40 feet, instead of 30 as in fig. 192. By constructing the parallelogram, making *a d* equal to 10, and drawing *d f*, *d e* parallel to *a c*, *a b*, the distance *a f*, or *f e*, will be found to be equal to nearly 7, thus showing the united pressure on the two beams to be equal to 14 tons, an increase of 2 tons, in consequence of the inclination being increased. In both these instances the weight is equally supported by the beams, where the beams differ in their amount of inclination: the

amount of pressure which each sustains is found by the same process. Thus, in fig. 193 B, the distance *a d* being as before 10, *a c* is 7, and *a f* $12\frac{1}{2}$—showing the united pressure to be $12\frac{1}{2}$ tons.

Inclined beams, supporting weights at their upper extremity, as *b* fig. 194, exert a pressure on their feet as at *a*, in the direction of the length, as *b a*. The tendency of inclined beams is therefore to push the walls outwards, by which they are supported: the amount of this pushing pressure is estimated by the same process as before. In fig. 195 A, if the beams were free to move in the direction of the arrows 3, 4, the motion of their extremities would be horizontal—*a b* sliding in the direction *s g*, and *a c* in *s h*. If they were prevented from moving in this direction, but at liberty to fall vertically, as in the direction of the

Fig. 194.

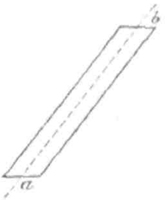
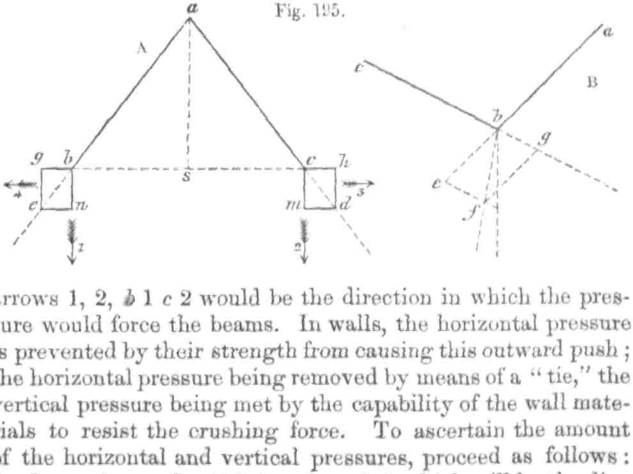


Fig. 195.

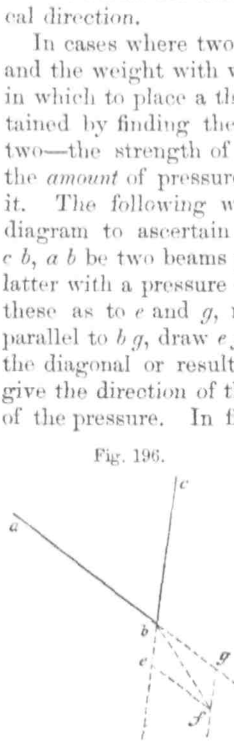


arrows 1, 2, *b* 1 *c* 2 would be the direction in which the pressure would force the beams. In walls, the horizontal pressure is prevented by their strength from causing this outward push; the horizontal pressure being removed by means of a "tie," the vertical pressure being met by the capability of the wall materials to resist the crushing force. To ascertain the amount of the horizontal and vertical pressures, proceed as follows: Produce *a b*, *a c*, fig. 195 A, to *e* and *d*, which will be the line of direction of their pressure. Make *b e*, *c d* equal to the pressure, in tons or pounds, to which each beam is subjected—in this case 6—as in fig. 193; draw *n e*, *m d* parallel to the line *s b*, *s c*; and *d h*, *e g* parallel to *b n*, *c m*. Take the line *b g*, *c h* from the same scale, which will represent the amount

of horizontal pressure, and *c m*, *b n* the vertical—the former in the example being 4, and the latter 5. By the use of the "tie," as already pointed out, the horizontal pressure is removed from the walls, and it is confined entirely to a vertical direction.

In cases where two beams are given with their inclination, and the weight with which each is pressed, the best position in which to place a third beam to support these two is ascertained by finding the direction of the thrust exerted by the two—the strength of the third beam being calculated from the *amount* of pressure which the two beams will exert upon it. The following will show the process of working the diagram to ascertain these points. Thus, in fig. 195 B, let *c b*, *a b* be two beams pressing in the direction of *c b*, *a b*, the latter with a pressure of 10 tons, the former with 8. Produce these as to *e* and *g*, making *b e* = 10, and *b g* = 6; from *e*, parallel to *b g*, draw *e f*, and from *g*, parallel to *a b*, *g f*. Draw the diagonal or resultant *b f* of the parallelogram—this will give the direction of the pressures, and its length the amount of the pressure. In fig. 196, *b f* shows the direction and represents the amount of the pressure exerted by the two beams, *a b*, *c b*, the pressure of *a b* being 10 tons, and *c b* 6. If the two beams are to be supported by one beam, it will have to be inclined in the direction of *b f*, figs. 195 B, and 196.

Fig. 196.



As in the case of "roofs," the weight which they support is not applied at the upper extremities of the inclined beams, but spread over the whole extent of their length—the pressure is not, as before (fig. 195 *a*), exerted in the direction of their length. To ascertain this, and also the amount, proceed as in fig. 197 A. Let *a b*, *a c* be the two beams—find the centre of gravity of each beam in the points *d e*; through these draw lines *d f*, *e g*, perpendicular to *b c*. Join *a f*, *a g*, and *b f*, *c g*, *b f*, *e g* give the directions of the thrust. To ascertain the amount of pressure, make *f h*, *g m* equal to, say 6 tons—from *h m* draw *h n*, *m o* parallel to *a c*; the distances *f n*, *g o* represent the amount of the pressure in the

direction of *f b*, *g c*, and *h n*, *m o*, the amount in the direction of the arrows 1 2. In fig. 197 A, the inclined beam is in the

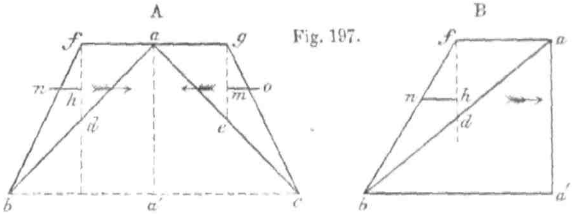


Fig. 197.

direction of *a b*—the letters are the same as in fig. 197 B—from this will be seen the nature of the strains and their amount.

An important point is to ascertain, in an assemblage of beams, the parts which act as "struts," and those which act as "ties." A rope or chain will act in all cases as the latter, the resistance it has to meet being that of "tension." Note the "sustaining forces," or the supports, whatever be their direction, and also the direction in which, if free to move, the weight or "straining force" would fall. All the supports, which are in the side of a line which the weight would occupy, if left unsupported, are "struts," all the other supports are "ties." Thus, in fig. 198, the dividing line is thus found: Let *a d* be the direction of the weight; in this as a diagonal construct a parallelogram, the sides of which will be parallel to the direction of the supports or sustaining forces *a b*, *a c*. Join the other diagonal of this as 1 2, at the point *a*, parallel to 1 2; draw the dividing line *a*. All the supports are in this case "struts," being on one side of the dividing line which the weight would occupy if left unsupported. In fig. 199, the direction of the weight is in the line *c e*, and is supported by *a d*, *a c*. Construct the parallelogram *c g*, *h f*, and join *g f*; through *c* draw a line parallel to this. The support *a c*, being above this, is a "tie," being stretched; *c d* is a "strut," and is compressed.

Fig. 198.

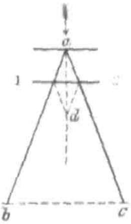
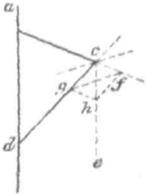


Fig. 199.



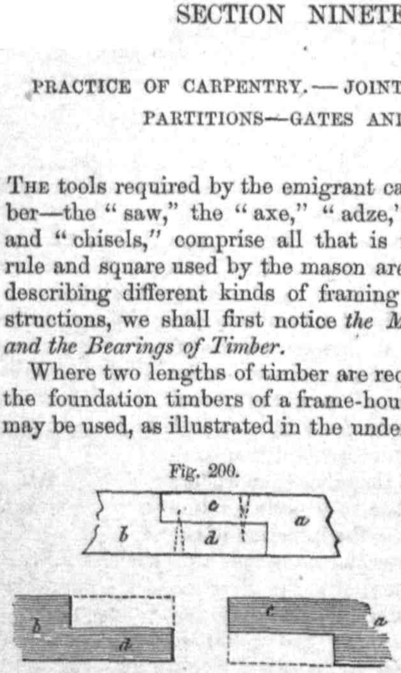
SECTION NINETEENTH.

PRACTICE OF CARPENTRY.—JOINTS—FLOORS—ROOFS—PARTITIONS—GATES AND BRIDGES.

The tools required by the emigrant carpenter are few in number—the "saw," the "axe," "adze," "auger," "hammer," and "chisels," comprise all that is necessary: the plumb-rule and square used by the mason are also required. Before describing different kinds of framing useful in various constructions, we shall first notice *the Manner of making Joints and the Bearings of Timber.*

Where two lengths of timber are required to be joined, as in the foundation timbers of a frame-house, the "half-lap" joint may be used, as illustrated in the under part of fig. 200, where *a b* are the ends of the beam to be joined: a piece is cut out on the under side of *a*, across its whole breadth, leaving a projection *c*; the same is done at the end of *b*, on its upper side, leaving a projection *d*.

Fig. 200.



The two being laid together, as in the upper part, and secured by trenails, the joint is complete. A trenail is formed out of hard wood, shaped something like *a*, fig. 201, and rounded as at *c* throughout its length: it is driven home by striking at the thick end. A "key" is square or oblong, as at *b*: a "double wedge" is shown at *g*. When inserted into the mortise made between the face of the two beams, the wedges being struck at both ends, as shown by the dotted arrows, the beams are brought in close contact. Where two beams are to be joined together, subject to compression, they

may be joined together, as in fig. 202, the ends *b a* forming a straight joint *c d* at right angles to the upper face: pieces of flat timber, the breadth of the faces of the beams, are then placed so as to embrace the four sides, and bolts passed through so as to secure the beams and casing. The scarf or half-lap joint, shown in fig. 200, may be executed as in fig. 203, where notches, as *c c*, may be cut in the faces of the joint, and keys *e e* driven in: this will prevent all moving from a cross strain. Another form of scarf joint is shown in fig. 204, where *a b*, *a b* upper part, are the beams to be joined; the ends *e e* being oblique, as shown

Fig. 201.

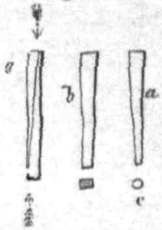


Fig. 202.

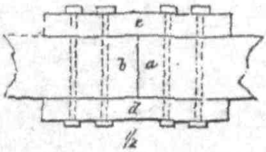
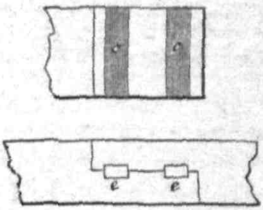
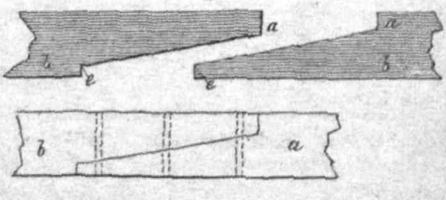


Fig. 203.



by the dotted lines. The under part shows the two beams laid together, and secured by bolts passing through each. When a beam is required to be of considerable depth, and no timber of sufficient size obtainable, the object may be obtained by the method illustrated in fig. 205, where two beams of same scantling are laid face to face, and bolted or pinned together by trenails *d d*, the beams being prevented from slipping on each other by means of the keys driven into notches, or mortises cut across the faces of the beams *a a*, *b b*, these being in depth equal to a little less than half the depth of the

Fig. 204.



key. Wall-plates, as *a b*, fig. 206, are joined together by a scarf joint, as shown: a double wedge may be inserted in a

Fig. 205.

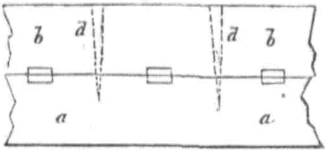
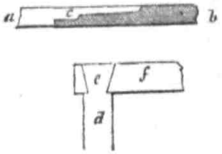


Fig. 206.



mortise at *c*; or the two may be pinned together at the joint. Where two wall-plates join at the corner of a wall, they may be joined by a dovetail joint, as at *e f d*. Where the end of one beam is connected with the face of another, the "mortise-and-tenon joint" is used, as illustrated in fig. 207: *c* is the tenon on the beam *d*; *b* the mortise on the beam *a a*; the tenon is inserted in the mortise, and a pin *f* driven through to keep them in place. Where the end of a beam is placed oblique

Fig. 207.

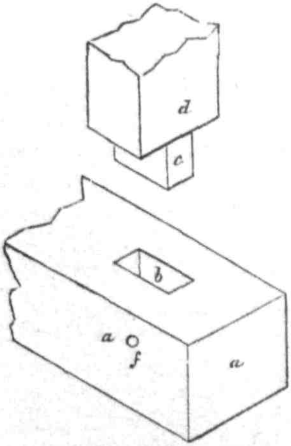
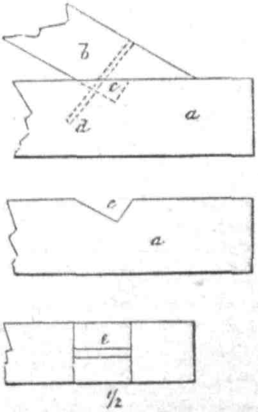


Fig. 208.



to the beam on which it rests, as the rafter *b* to the tie-beam *a*, fig. 208, the joint is made as in the upper diagram, the end *c* being at right angles to the face of *b*. The shape of the mortise in *a* is shown at *c*: it is not cut right across

the beam *a*, but a small projection or tenon, *e*, is made; this fits into the mortise correspondingly cut in the beam *b* at the foot *c*: an iron strap *d* is sometimes added, to prevent the strain upon the heel of the rafter. In place of the flooring joists lying on the wall-plate *a b*, as at *c c*, fig. 209, a mortise-and-tenon joint is made at *d*, a tenon *e* being left in the centre of the notch made on the wall-plate; *g* is a diagram representing the under edge of the joist *c c*, with the mortise *e*. Where one beam rests upon another, as *b* on *a a*, fig. 210, the

Fig. 209.

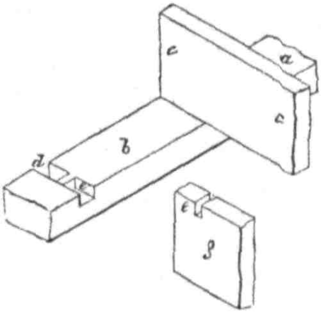
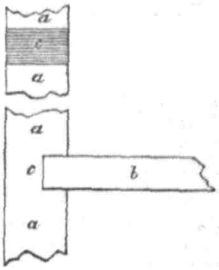


Fig. 210.



simplest joint is made by cutting a notch, as *c*, into which the end of the beam is placed. A more perfect form is shown in fig. 211, called the dovetail joint: *c* is the beam, with dovetail mortise; *a* the beam to be supported with dovetail tenon *b*; window and door frames are put together by either of these methods, or by the mortise-and-tenon joint in fig. 207. In fig. 212, under part, the method of joining a collar or tie-beam *c* with a rafter *a a* is shown; the end of the tie-beam *c* is cut as at *d e*, and a space, as *b*, cut out of the rafter. The upper diagram shows the two in connection. Where an angular strut *b*, fig. 213, rests against a king-post, the abutting surface, as *c c*, should be at right angles to the direction of the struts *b b*. This is shown in fig. 213, which represents the connection between the head of a king-post and the struts; and in

Fig. 211.

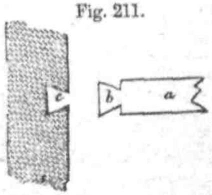
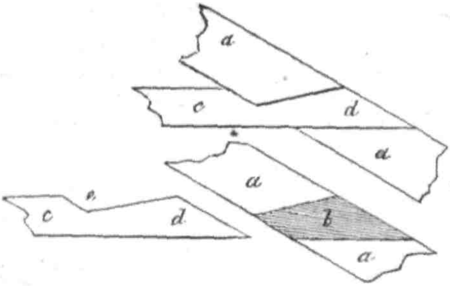


fig. 214, which represents the foot of a king-post and the struts. Where a lean-to roof is adopted, the bearing surfaces of the rafters or timbers employed should be horizontal, as at *a*, resting on the highest wall *a*, and *b* resting on the lower wall *c*, fig. 215.

Fig. 212.



We now come to the consideration of the construction of *Timber Floors.* The simplest method of making these is by placing boards squared at the edges, as *b b*, fig. 216, on the upper

Fig. 213.

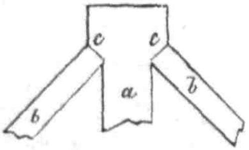
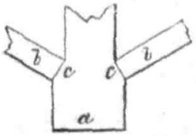


Fig. 214.



sides of the joists *a a*, and at right angles to these. For a room 12 feet square, the dimensions of the joists *a a* should

Fig. 215.

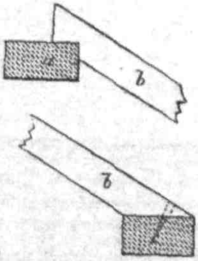
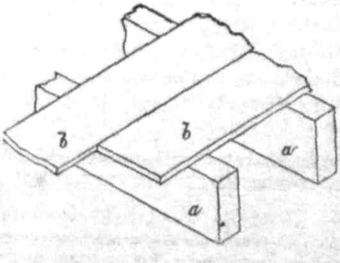


Fig. 216.



be 8 inches deep by 2½ thick, and laid on their edges, at a distance of 12 inches from centre to centre. All joists

should be thin and deep: when the length between the bearings is 10 feet, the size or scantling, as it is termed, should be 7½ inches deep by 2½ thick. These sizes are for fir. Where the bearing exceeds 9 or 10 feet, struts, as *c c*, *b b*, fig. 217, should be disposed between the joists *a a a*. Where the joists are from 7 inches by 2 to 8 inches by 2½, the dimensions of these struts should be 2½ inches wide by 1 thick. The distance between each pair of struts should be 4 feet. In place of this strutting, thin boards, ¾ inch thick, same depth as joists, may be placed between them, at a distance from each other of 2 or 3 feet—care being taken that the struts are all in the same line. The use of these struts between the joists is to prevent them from turning or twisting, when heavy weights are passing over them: by means of this strutting, joists of less dimensions than what may be requisite will make a stiff and strong floor. The flooring-boards *b b*, fig. 216, may be simply squared up on the edges, and nailed successively down over the joists, beginning at one side and gradually going over to the opposite. Where a close-fitting floor is required, the edges of the boards may be tongued and grooved. As the ends of the flooring-boards are left rough at the walls, in houses where appearance is looked after, the emigrant may adopt the plan of fixing what is termed a "skirting-board." In a room 10 feet square the depth of this may be 6 or 7 inches by 1 thick; the upper edges may be finished square off as at *c*, fig. 218, or bevelled off as at *b*, or moulded as at *a*. In the upper floors of houses of a large size, double-framed floors are used, of a more complicated construction than the single floor we have described. In the class of house, however, required by the emigrant, the single floors in fig. 216 will do well enough for the bedroom story. Along the under side, cross pieces, 2 inches by 1 inch thick, should be nailed at right angles to the line of joists, and about 4 feet apart; to these the laths to support the plas-

Fig. 217.

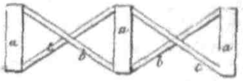
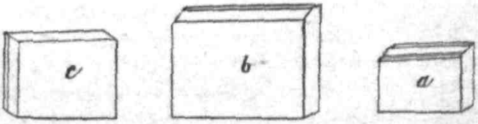
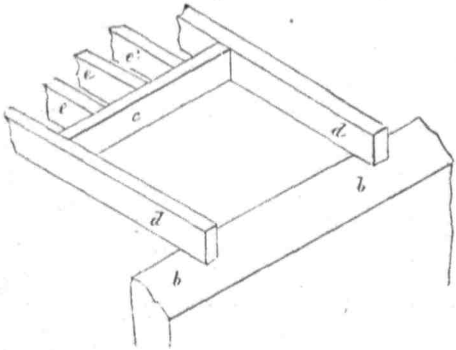


Fig. 218.



tering are nailed. If the laths employed are only 3 feet long, the distance between the cross pieces should be 3 feet. Where the openings of staircases, flues, or chimneys occur, thus interrupting the bearings of the joists on the walls, the contrivances called "trimmers" must be adopted. In fig. 219,

Fig. 219.



the arrangement of joists for the "well-hole" of a staircase is shown: the beams *d d*, which are placed on the walls *b b*, at opposite sides of the opening (or chimney-flues, as the case may be), bear on the wall at both sides, as in the case of joists; these support the trimmer *c*, which is mortised into them. This trimmer is at right angles to the line of joists. The joists *e e e* are mortised at one end into the trimmer *c*, and rest at the other on the wall in the usual manner. The trimmer *c* is of same dimensions as the trimming joists *d d*. The trimming joists must be increased in dimensions according to the number of joists, as *e e e*, which are mortised into the trimmer: thus, if the size of common joists, *e e e*, is 8 by $2\frac{1}{2}$, and the trimmer *c* supports three of these, add $\frac{3}{8}$ths of an inch to the thickness of the trimmer joists, the size of which will then be 8 by $2\frac{7}{8}$. Generally the thickness of the trimmer joists is increased by 1 inch, but where the distance of the trimmer *c* from the wall does not exceed 4 feet, the addition of a little more than $\frac{1}{8}$ inch to the thickness of the trimming joists for every common joist, as *e e e*, which the trimmer *c* supports, will be ample allowance.

In fig. 220 we give an illustration of a double floor: *a a, a a* the binding joists; *b b b, b b b* the common joists, *c c* the ceiling joists, *d d* the flooring planks. In fig. 221 we illustrate a double-framed floor, in which *a a* is

a girder, which carries the binding joist *b b*; *c c* the common joists, *d d* the flooring planks, *e e* the ceiling joists.

Fig. 220.

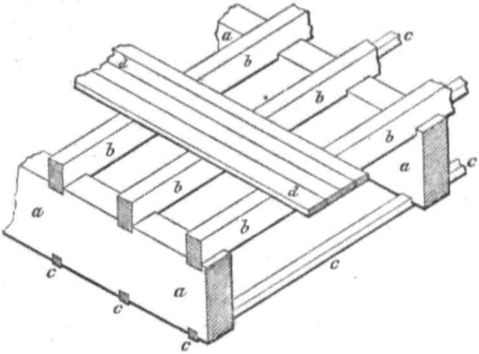
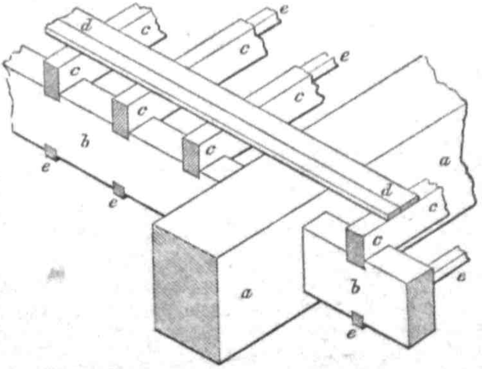


Fig. 221.



We now come to the consideration of *Roofs*. The simplest of all roofs, and one which will be found quite good enough for many purposes of the emigrant, is the "lean-to" shown in fig. 222, where *b* is the rafter, resting on the wall-plates *a c*: where a small closet or outhouse is constructed towards the side of *a*, the beam *b* may be prolonged as at *d*, to form its roof. Where the distance between the walls is from 10 to 12 feet, the dimensions of the rafter *b* may be 5 inches

by $2\frac{1}{2}$, and placed at a distance of 4 feet from each other; the boarding on which to nail the roof-covering is nailed on the top of their beams, at right angles to their line of direction. Where the span of the roof, or distance between the walls, is from 14 to 18 feet, a lean-to roof should be constructed, with a simple truss, as in fig. 223, where *a* is the beam, 8 inches by 3, resting on the wall-plates *b b*, 4 by 3; the

Fig. 222.

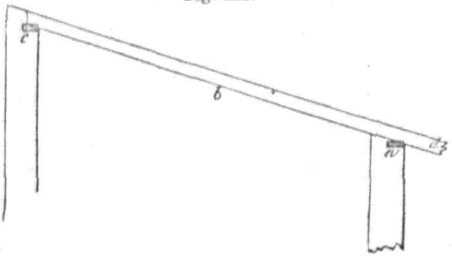
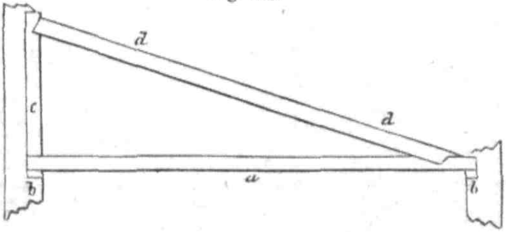


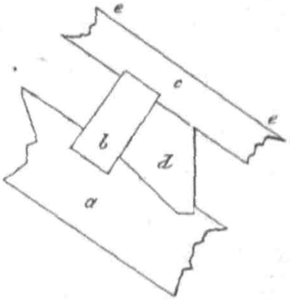
Fig. 223.



rafter *d d*, 4 by 3, abuts at one end on the tie-beam *a*, and at the other on perpendicular piece *c*, 4 by 3. This piece *c* may be dispensed with, and the rafter *d* abut on a wall-plate let into the wall as in fig. 222 at *c*. These trusses may be placed at a distance of from 5 to 6 feet apart. The boarding on which the roof-surface is placed, rests on what are called common rafters: these, in like manner, are nailed on purlins mortised into the upper edge of principal rafters *d d*. The purlins run at right angles to the line of rafters *d d*, as *j j*, fig. 228; the common rafters, *h h*, parallel with the principals, and abutting at one end on the ridge-pole, and at the other on a pole-plate *b*, fig. 228, on the wall *c*. In fig. 224 the manner of connection is shown, where *a* is the principal rafter, $4\frac{1}{2}$ by 3; *b* the purlin, 5 by 3, mortised at its lower end to the face of the

principal, and abutting on the piece *d*, mortised into or nailed on the principal. The common rafter *c*, 3 by 2, is mortised into or nailed upon the purlin, and the boarding to receive roof surface is nailed on the upper surface of *c*, as at *e e*, at right angles to the rafter *c d*, and parallel with the purlins *b*.

Fig. 224.



In fig. 225 we give—to a scale of $\frac{3}{16}$ths of an inch to the foot—another arrangement of a lean-to roof: *a a a* walls, *b* tie-beam, *c c* wall-plates, *d d* rafter, *e* strut, *f* upright, *g* purlin, *h h* common rafters or spars, *i* pole-plate. Where a lean-to roof is not admissible, but one of the ordinary kind of sloping roof required, a simple form is shown in fig. 226. The slope of this roof

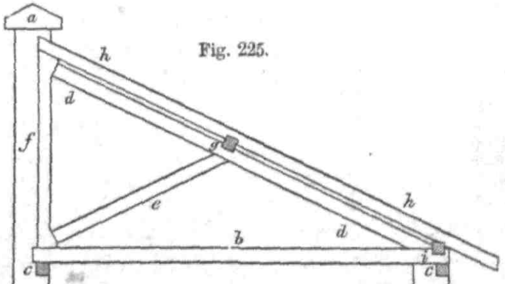


Fig. 225.

is one-third its span, or the distance between the walls, inside measurement. The two beams *b b*, 9 by 3, abut against each other at the upper end, and rest on wall-plates at the other: these are at *a a*, and are 4 by 2½. A collar *c* is placed across the two rafters, at a height of one-half the slope: the dimensions of this should be 5 by 3. The simple trusses thus formed should be placed at a distance of 4 feet from each other, and the slate-boarding nailed at once on the upper edge, without the intervention of purlins or common rafters. The span of roof in this example is 16 feet.

The gutter for conveying the rain water is fixed at *b*. The manner of notching the rafter to the wall-plate is shown in

Fig. 226.

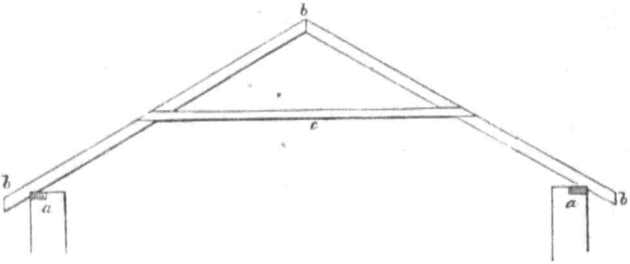


fig. 227, where *b* is the wall-plate, *a* the rafter, *c* the notch. For roofs of a greater span—as from 20 to 25 or 30 feet—a truss, as represented in fig. 228, may be used: *c c* the walls; *d d* (the span in this example is 20 feet) the tie-beam, 9 by 4, resting on wall-plates *a*, 4 by 3; *g g* the principal rafters, 4 by 4; *j j* the purlins, 5 by 3; *h h* the common rafters, 3½ by 2, abutting on the pole-plates *b b*, 6 by 3, and on a ridge-pole 11 by 1; the struts *f f*, placed beneath the purlins, are 4 by 3, and abut on the piece *e*, 4 by 3, let into the face of the tie-beam *d d*. For a span of 25 feet, the dimension of *d d* should be 10 by 5; the principals *g g*, 5 by 5; the struts *f f*, 5 by 3; the common rafters *h h*, 4 by 2½; the wall-plates *a a*, 4½ by 3½.

Fig. 227.

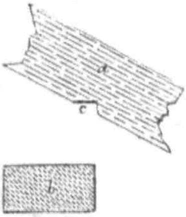
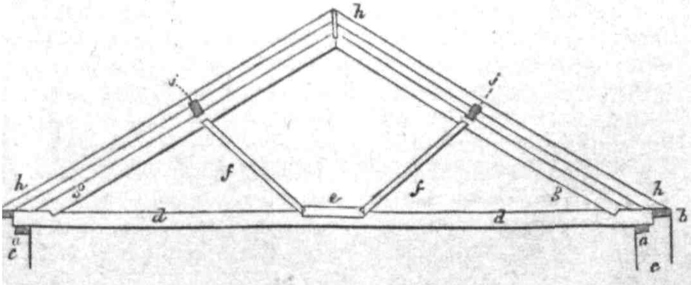


Fig. 228.



In fig. 229 we give a half elevation of a *king-post truss* adapted for a roof of 25 feet span: *a* wall-plate, *b* tie-beam, *c* king-post, *d* principal rafter, *e* strut or brace, *f* purlin, *g* pole-plate, *h* common rafter, *i* ridge-pole. In fig. 230 we give a half *elevation of a queen-post truss*, adapted for a roof of 30 feet span: *a* tie-beam, *b* queen-post, *c* brace or strut, *d e* principal rafter, *f* purlin, *g* pole-plate, *h* common rafter, *i* ridge-pole. In this form of truss there is no centre piece, so that a clear space is obtained above the tie-beam. The queen-posts, of which one is at *b*, are kept apart by the straining-beam *k*. In fig. 231, the king-post is supplied by a wrought-iron rod *a*; *b c* the principal rafter, *d* the strut or brace, *e e* the common rafter, *f* the cast-iron rafter-box, in which the ends of the rafter *b c* are placed.

Fig. 229.

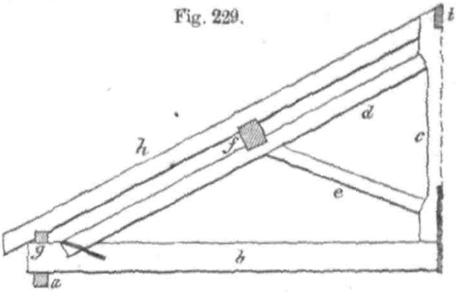


Fig. 230.

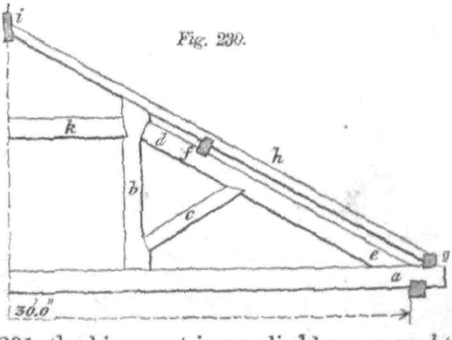
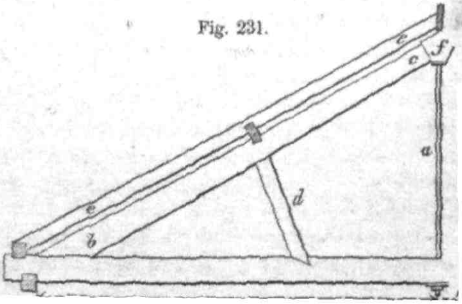


Fig. 231.



In fig. 232 we give—to a scale of $\frac{1}{8}$th inch to the foot—the elevation of a "*curb*" or "*mansard*" truss, for a roof in which space for an attic room is required. In fig. 233 we give an elevation of a truss for a *flat roof;* and in fig. 234, a truss for a *Gothic or high-pitched roof*, in which an iron suspension-rod or tie-bolt *a* is used—a cast-iron rafter-box *b* being employed, in which to house the ends of rafters *c c*. Fig. 233 is to $\frac{1}{8}$th inch, and fig. 234 to $\frac{3}{16}$ths of an inch scale.

Fig. 232.

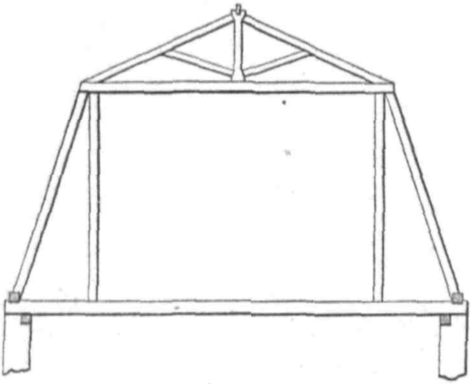
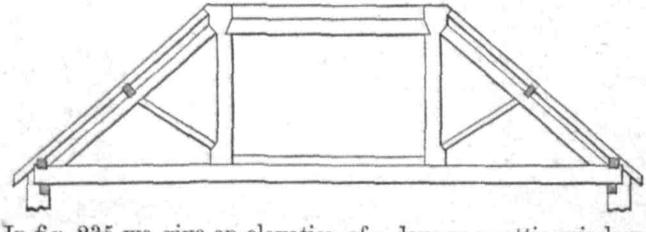


Fig. 233.

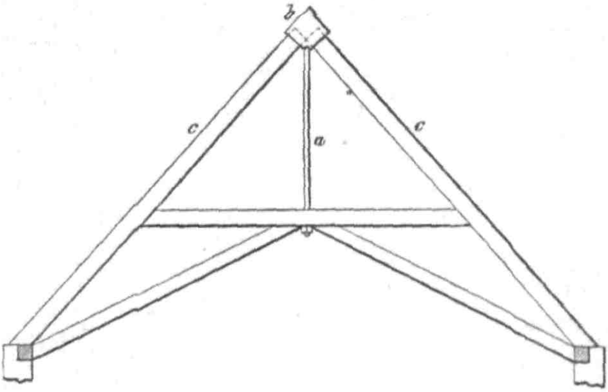


In fig. 235 we give an elevation of a dormer or attic window, and in fig. 236 a section of the timber-work of the same—both being drawn to a scale of $\frac{1}{8}$th inch to the foot. In fig. 236, *a a* is the rafter of roof.

A side view of part of wall, with gable having slope, as the slope of roof in fig. 226, is shown in fig. 237 : *a a* is the front wall, *a a* the gable, *b b* the ridge-pole, *c c* the rafters, *d d* the boarding on which the roof-covering is fixed. A rafter, same dimensions as *c c*, may be let into the face of the gable as shown at *a a*, on which to nail the boarding: this will not be necessary except in cases as in the diagram, where the last

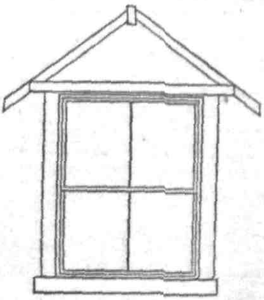
rafter is at some distance from the gable. This diagram represents the side arrangement of timbers in a roof similar

Fig. 234.



to that in fig. 226. In cottages of a better description, where objections may be made to having the timbers of the roof seen from the inside of house, a ceiling may be formed by having stays *b* stretching across the span, resting on the wall-plate *a*, fig. 238, the rafter *c* being notched on to both, as in fig. 227. On the under side of these stays—which will be placed at distances apart corresponding to the distance between the rafters—the cross pieces, 2 by 1, are nailed, on which to nail the laths for plastering. The method of forming

Fig. 235.



a roof with ceiling is shown in figs. 239, 240, which are drawings of a roof adapted for a cottage, of which the plan is given in fig. 3, and drawn to a scale of $\frac{1}{8}$ inch to the foot: fig. 239 is the end view, and fig. 240 the side view. In fig. 239, *c c* is the wall, *d* the ceiling stays or joists, 4 inches by 2; *c c* the wall-plates, 4 inches by 2; *b b* the rafters, 4 inches by $2\frac{1}{2}$; *a* the ridge-pole, 7 inches by 1. In fig. 240, *a a* the

walls, *b b* rafters, laid on the gables, of same dimensions as *d d*; *c c* the ridge-pole, *e e* the ceiling joists or stays. Figs. 241, 242, 243, represent the drawings of a roof adapted for the cottage of which a plan is given in fig. 5, and exemplifying the method of arranging the timbers where a projection is found in the building, and one roof meets another at right angles. Fig. 241 is the plan of roof and walls: *a a a a* the walls, *b b b* the wall-plates, 4 inches by 2; *d d* the ridge-pole, 7 inches by 2½, of the longest part of house; *c c* the ridge-pole, 7 inches by 1½, of the projection containing scullery, &c. (see fig. 5); *e e*, *e e* the hip-rafters, 6 inches by 2; *f* the rafters, 6 inches by 2; *g h* show the direction of slate-boarding on the parts of the roof. In fig. 242 is given a view of the roof taken through a little on one side of *c c*, fig. 241; *h h* is the ridge-pole of projection of scullery, resting one end on the top of gable *a a*, and abutting against the ridge-pole corresponding to *d d* in fig. 241 at the other; *f* the rafters of the long part of the house (living and bed room, see fig. 5); *d* the ceiling

Fig. 236.

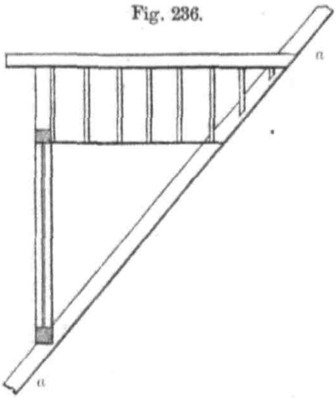


Fig. 237.

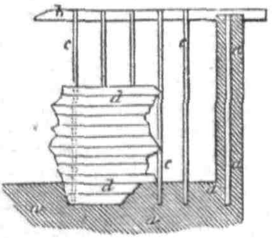


Fig. 238.

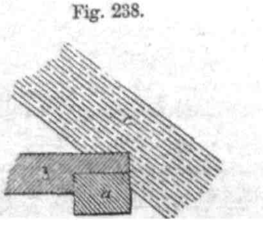
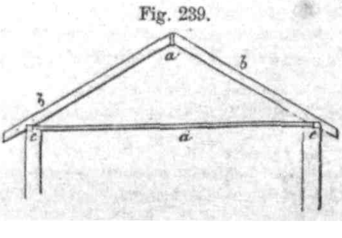
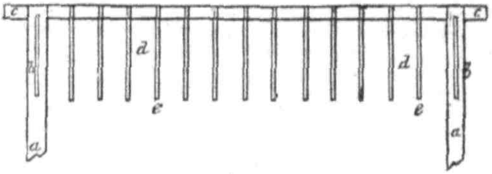


Fig. 239.



stays, 4 inches by 2, resting on the wall-plate on one end, and at the other on the partition *m*, dividing scullery from other rooms

Fig. 240.



(see fig. 5); *g* the hip-rafter, corresponding to *e e*, fig. 241; *n n* the common rafters, *s s* the wall at end of water-closet (see

Fig. 241.

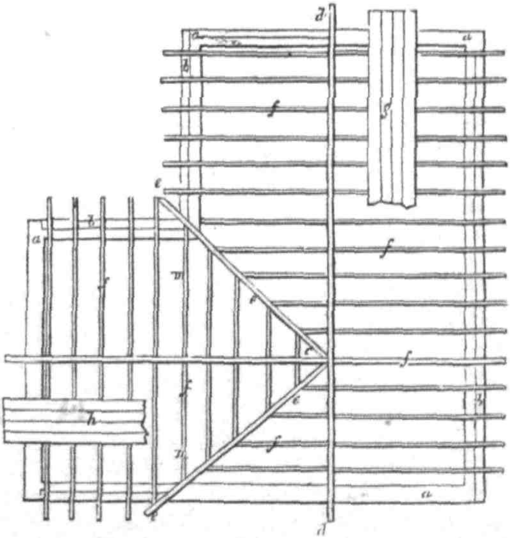
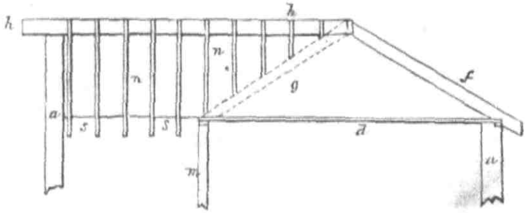


fig. 5). Fig. 243 shows the appearance of roof as taken through a line along the living and bed rooms, a little to the right of the ridge-pole *d d*, fig. 241: *o o* is the ridge-pole corresponding to *d d*, fig. 241, and *o* ridge-pole to *c c*, same fig.; *b b* the rafters corresponding to *n n*, fig. 242; *n n* the rafters corresponding to those in fig. 241 marked *f*; *a a* the walls. In fig. 244 the arrangement of timbers shown

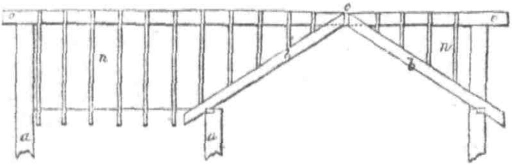
at *c c*, fig. 241, is given on a large scale: *a a* is the ridge-pole, corresponding to *d d*, fig. 241, and *b* that corresponding to *c c*; *c c* are the hip-rafters corresponding to *e e*, fig. 241.

Fig. 242.



Instead of mortising the ridge *b* into *a*, as shown in fig. 244, they may be spiked together as in fig. 245. Figs. 246,

Fig. 243.



247, 248, are drawings ($\frac{1}{16}$ inch scale) of a form of a roof adapted to the house in figs. 9, 10, and termed a "hip-roof." Fig. 246 is the plan, 247 the end, and 248 the side view. The ridge-pole *a*, fig. 246, is 6 feet 6 inches long, and 4 inches by 3; the hip-rafters *d d* (figs. 247, 248), 4 inches by 3, abut at the outer ends on the wall-plates at the corners *e d c b*, fig. 246. The rafters which are placed between the hip-rafters, and gradually decrease in length, are termed "jack-rafters," and are of same scantling as the hip. The ceiling stays *c*, fig. 247, are 4 inches by $2\frac{1}{2}$, the wall-plates same size. Where two roofs meet, the gutter is formed as in fig. 249. Where the rafters project over the wall, as in the example in fig. 226—which in the majority of the simpler constructions will be the case—the gut-

Fig. 244.

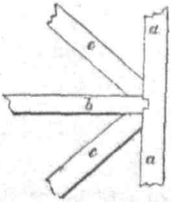
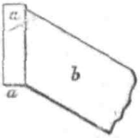
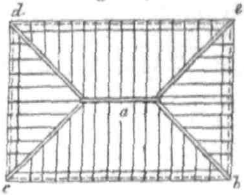


Fig. 245.



ters are made in a variety of ways, as shown in the following figures: In fig. 250, *d* is the rafter, *c* the gutter, formed by bending thin iron or zinc into the shape required, and nailing it to the end of the rafter. Care must be taken to give the gutter a gentle slope throughout its length, to prevent the water stagnating in any part, and to lead it as quickly as possible to the "down pipe," carrying it to the

Fig. 246.



rain-water tank or barrel. This slope is given to it by marking off on the end of the first and last rafter, between which the length of gutter is fastened, a line at the same distance from the under

Fig. 247.

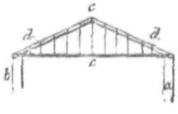
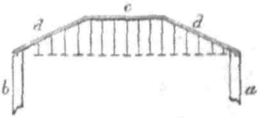


Fig. 248.



side—say this, 4 inches; the upper edge of the gutter, as *a*, is nailed at the mark, and the other end of the gutter at the other rafter *b*, at a short distance *below* the mark: this will give the proper fall. The inclination may be, for every 15 feet in length, a fall of 1 inch. In fig. 251 the gutter *b* may be made

Fig. 249.

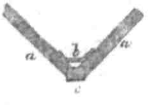
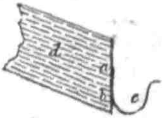


Fig. 250.



of wood 3 inches square in the inside, and nailed to the rafter *a*, as shown. Mr Downing, in his work on *Country Houses*, figures two simple methods of forming gutters at the end of rafters: these are shown in figs. 252, 253. In fig. 252, *a* is the wall, *b b* the rafter, *c* a triangular piece

Fig. 251.

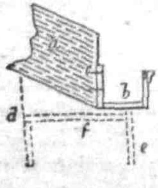
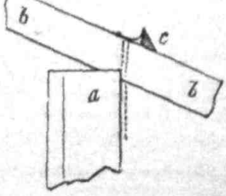


Fig. 252.



of wood nailed to the rafter, giving a support to a curved half pipe of zinc or iron, shown in the diagram. In

fig. 253 the half-circular bed for the pipe-gutter is cut out of the rafter: this looks well from the exterior, as no projection is seen. In both these plans the down pipes, for leading the rain water to the lower level, can be at once taken from the gutters, flush or level with the outside line of wall, as shown by the dotted lines. In the other forms of gutter described, if itis wished to take the down pipe along the wall, bends or turns must be made to bring it from the projecting gutter to the face of the wall. Thus, in fig. 251, the simplest method of leading the rain water from the gutter *b*, would be to take a pipe, shown by the dotted line *e*, to the barrel beneath. This, however, would be unsightly; to obviate which, a return or bend *f* might be made to the wall *d*, and the pipe laid down its face, as is usually done. In the form of roof in fig. 228, the gutter is supported by pieces of timber *c*, fig. 254, placed beneath the wall-plate *b*, at intervals corresponding to the rafters *e*. The front face of the gutter *d* may be ornamented with a mould-piece *f* nailed to it. The size of projecting piece *e*, or "cantaliver" as it is termed, may be, for roofs of ordinary size, 4 inches wide by 1 thick; the size of gutter inside may be from 3 to 4 inches wide and deep, inside measurement.

Fig. 253.

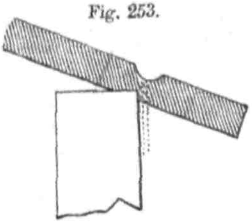


Fig. 254.

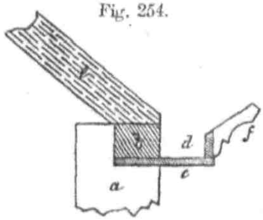
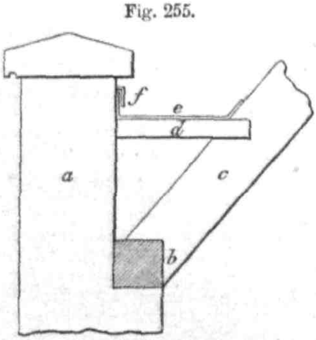


Fig. 255.



In fig. 255 we give a section of another form of gutter, in which *a* is the wall, *b* the wall-plate, *c* the rafter, *d* the gutter-board, *e* the lead lining, *f* the flushing.

We now purpose illustrating a few forms of *Partitions of Timber*—these are termed "quartering partitions." A simple form where two doors are required, as in cases something like that in fig. 3, is shown in fig. 256, where *a a* are the walls, 14 feet across; *f f* the line of flooring; a beam *c* is placed beneath the ceiling, 4 inches by 3, and let into the wall at each end; posts *h h*, 4 inches by 3, are mortised into the under side of beam *c*, and spiked to the floor at lower end: the distance between these and face of wall is 3 feet: braces *e e* are placed between *h h* and wall, 6 feet 6 from floor line, mortised at one end to the posts, and let into the wall at the other. Half-way between the line of floor and under side of *c*, a horizontal brace is placed at *d*; the boarding, 5 inches by $\frac{3}{4}$ or $\frac{1}{2}$ inch, is nailed parallel to the walls, on one side of the posts and braces. A form of partition, having one door in the centre, is shown in fig. 257: *a a* the walls, *b* horizontal beam, 4 inches by 3; *g g* posts, do.; *d e* do., forming doorway; *f f* struts, 4 inches by 2, abutting at the upper end against uprights *d e*, and at the lower end against wall and floor. In this case the boards are placed horizontally.

Fig. 256.

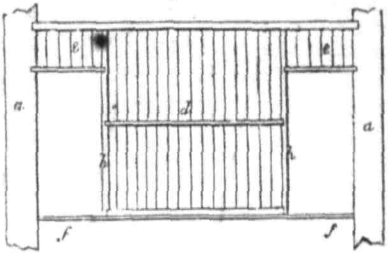
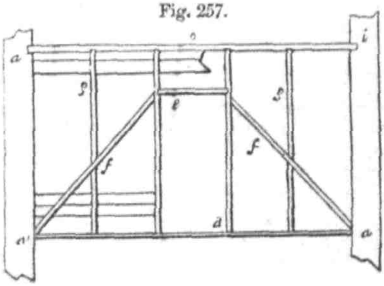


Fig. 257.



In figs. 258, 259, 260, we illustrate three forms of quartering partitions, drawn to a scale of $\frac{3}{16}$ths of an inch to the foot: *a a*, *a a* queen or upright posts, *b b* sills, *c c* heads, *d d* braces, *e e* straining pieces, *f f* quarterings. In fig. 261 we illustrate a trussed partition, adapted for a 28-feet span.

Fig. 258.

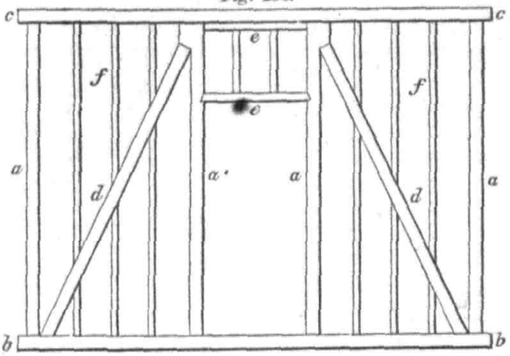


Fig. 259.

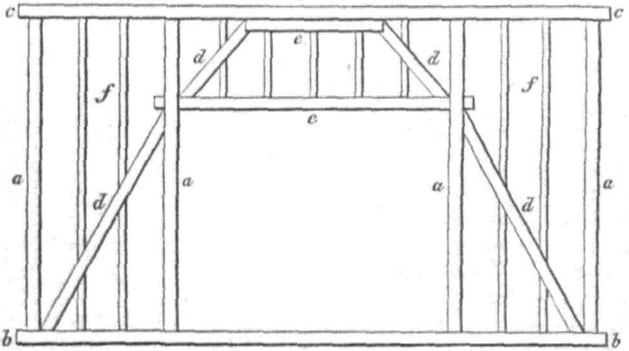
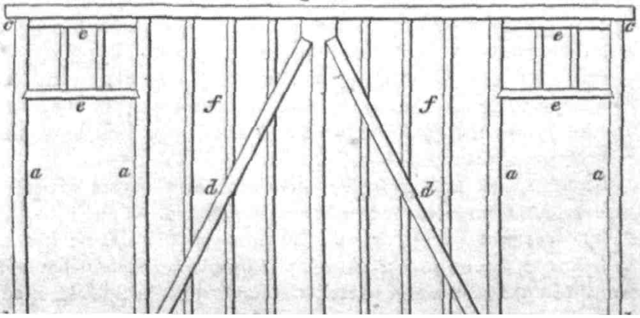
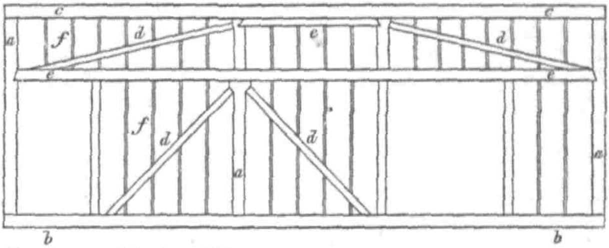


Fig. 260.



This form is used where the partition is not supported below by a wall.

Fig. 261.



In figs. 262 to 267 inclusive, we illustrate various forms of *joints of heavy timbers, in which iron straps are employed:* the whole are drawn to $\frac{3}{4}$ths of an inch to the foot. Fig. 262 illustrates the junction of the foot of a rafter *a*, with the tie-beam *b*, *c* being the iron strap. Instead of being bolted by an eye at *d*, it may be extended as shown by the dotted lines *e*. Fig. 263 shows the strap used to connect the foot of king-post *a*, braces *b b*, with the tie-beam *c*; fig. 264, that used to connect head of king-post *a* with braces *b b*; fig. 265, that for connecting straining beam *a* and brace *b* with head of queen-post c; and fig. 266, that

Fig. 262.

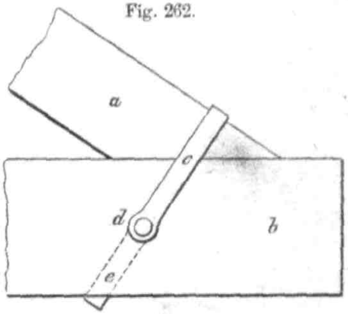
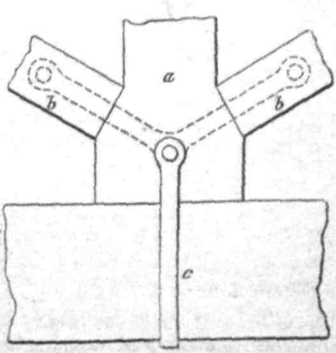


Fig. 263.



for connecting the collar beam *a* with rafter *b b*. Fig. 267 illustrates a form of strap used for the junction of four timbers.

Fig. 264.

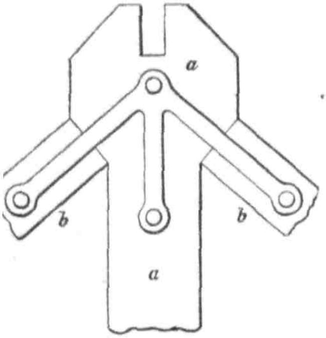


Fig. 265.

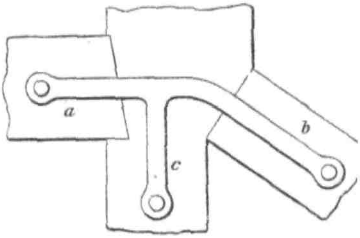


Fig. 266.

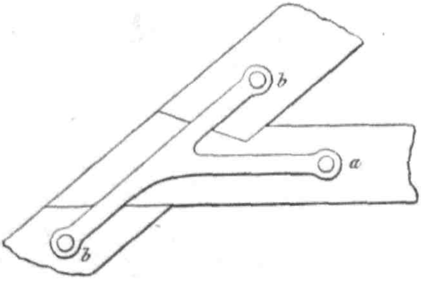


Fig. 267.

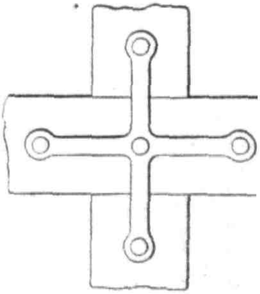
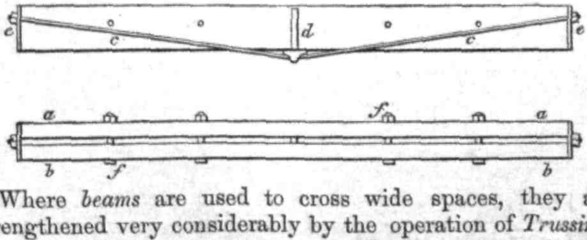


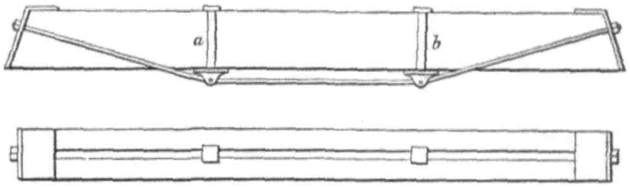
Fig. 268.



Where *beams* are used to cross wide spaces, they are strengthened very considerably by the operation of *Trussing*. Fig. 268 illustrates a common method of trussing a beam:

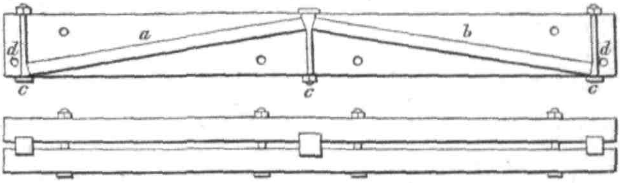
a a, *b b* show the two flitches between which the truss rod *c c* is placed. This passes over—in the centre of its length—an iron stud *d*, and the ends are passed through two iron plates *e e* placed at the ends of the two flitches, and secured by nuts. The two flitches are secured together by the bolts and nuts *f f*. This is drawn to a scale of $\frac{1}{4}$th of an inch to the foot. Fig. 269 illustrates another method, in which two

Fig. 269.



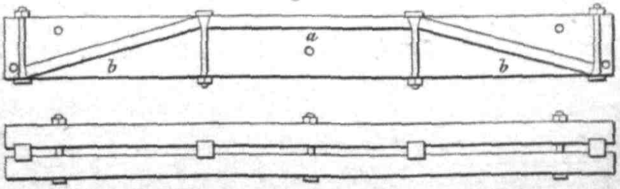
studs, *a* and *b*, are employed—scale $\frac{3}{16}$ths. Fig. 270 illustrates the form of the king-post truss, in which two flat struts

Fig. 270.



or braces of cast-iron *a b* are used, butting at their lower and upper ends against the studs *c c c*; *d d* are pins to resist the pressure of the struts *a b*, on the outer studs *c c*. Fig. 271

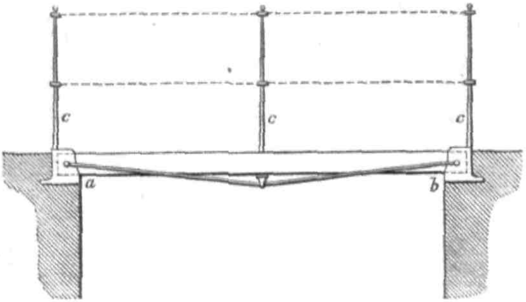
Fig. 271.



illustrates the queen-post truss, in which a straining piece *a*, and struts *b b*, are employed. Scale of figs. 270, 271, same as fig. 269.

Bridges.—Trussed beams may be applied with economy and efficiency to the spanning of ravines, &c., where a simple form of bridge is required. Fig. 272, drawn to a scale of ¼th inch

Fig. 272.



to the foot, illustrates a foot-bridge formed of a trussed beam. The ends of the beam are housed in cast-iron boxes *a b*; *c c* are the standards to support the hand-chains. In fig. 273 we give an enlarged drawing, one-fourth full size, showing the method of constructing the hand-chains: *a a* is part of the vertical iron standards; a stud, *b*, is passed over this; this stud is provided with snugs and eyes *c c*, to which the horizontal chains, as *f*, are connected. In the plan *d* is the central aperture, through which the standard is passed; *e e* the snugs. In figs. 274 to 277 we illustrate

Fig. 273.

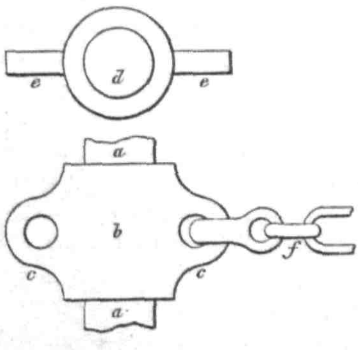
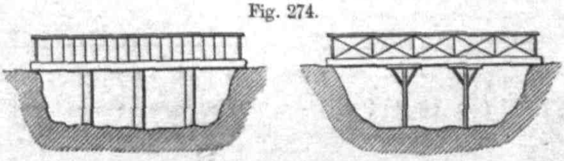
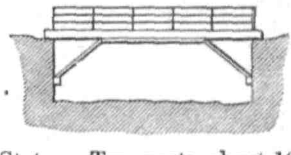


Fig. 274.



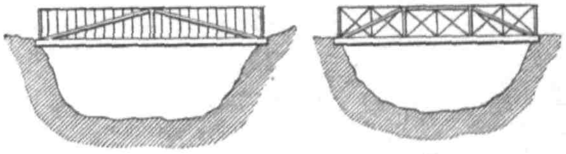
several forms of wooden bridges. Figs. 274, 275, and 276 A, are adapted for a span of 25 feet; fig. 276 B, for a span of 40 feet; and fig. 277 for 50 feet. Fig. 276 A, is on the king-post truss, and figs. 276 B and 277 on the queen-post truss principle.

Fig. 275.



Gates.—A simple form of field-entrance—for gate it cannot be termed—is largely adopted in many of the farms of the United States. Two posts, about 10 or 12 inches diameter, and some 6 or 7 feet long, are driven

Fig. 276.



A B

into the ground, at a distance from each other corresponding to the width of entrance required (a gap in the fence being left for this purpose): at equal distances holes are cut in these posts through and through, in the direction of their length — say four holes in each post: poles are laid horizontally between the posts, the ends resting in the holes. These poles are removed when entrance or exit is required. In fig. 278 we give the elevation of a form of gate to be made of wood: *a c* the heel-post, *b d* the head-post, *c b* the top rail, *a d* the bottom rail, *a b* the diagonal strut, rising from the foot *a*, and terminating at *b*. In fig. 279 another form is shown. The struts, instead of reaching across the diagonal form *a* to *c*, terminate in the centre *b*: this is not so strong a form of gate as

Fig. 277.

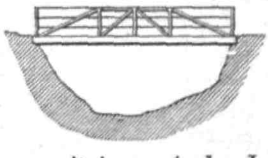
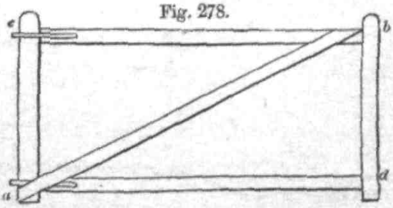


Fig. 278.

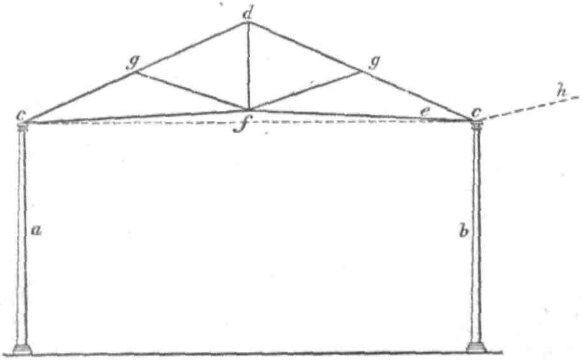


SECTION TWENTIETH.

IRON FRAMING—ROOFS AND COLUMNS.

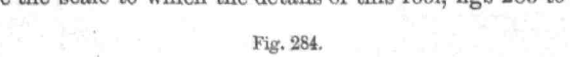
Roofs.—In fig. 283 we give a skeleton diagram of an iron truss roof, supported on iron columns *a b*. The scale to which

Fig. 283.



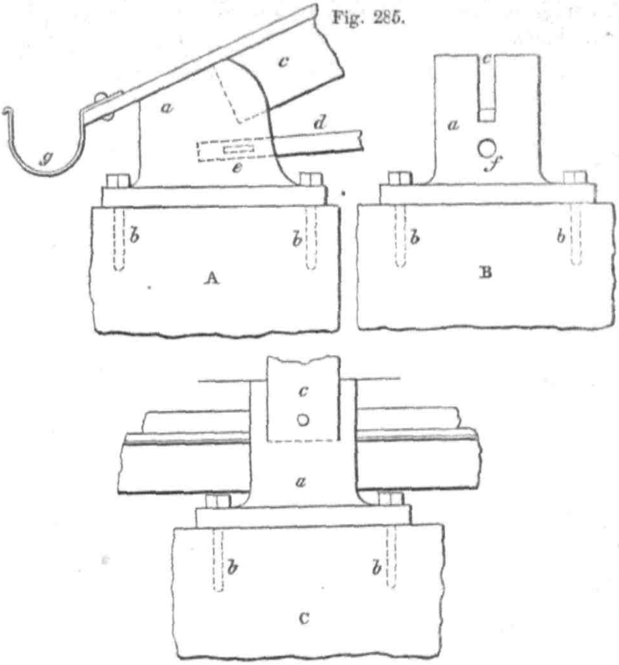
this is drawn is $\frac{5}{16}$ths of an inch to the foot. In fig. 284 we give the scale to which the details of this roof, figs 285 to 292

Fig. 284.



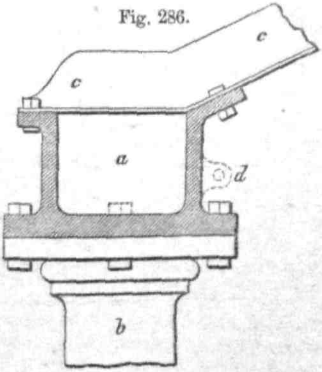
inclusive, are drawn. Fig. 285 gives the detail of the shoe, or rafter-box, in which the lower ends of the rafters *c d*, fig. 283, are housed. In fig. 285, A is the side, B the end, and C the front elevation; *a* the shoe secured to the wall, or top of column, by the bolts *b b*; *c* the rafter, *d* the rod, corresponding to *e f*, fig. 283. This is passed into an aperture *f*

Fig. 285.



in the shoe, and secured by a key *e*; *g* is the zinc gutter riveted to the projected top flange of rafter. Fig. 286 shows a method of forming rafter-shoe and gutter in one: *a* shoe bolted to top of column *b*; *c c* rafter; the tie-rod (*e f*, fig. 283) is jointed to the snug *d*, shown by the dotted lines. Fig. 287 illustrates another method, where *a* is the shoe, *b* the rafter, *c* the tie-rod, *d* the gutter, the water from which is led by the pipe *e e* to the hollow column *f*. A front view is given, showing

Fig. 286.



snugs *g*, to which the end of the tie-rod *c* is jointed; *h* is a side view, and *i* an edge view of the jointed end of tie-rod, with pin *k* for securing it to the snugs at *g*. Fig. 288

Fig. 287.

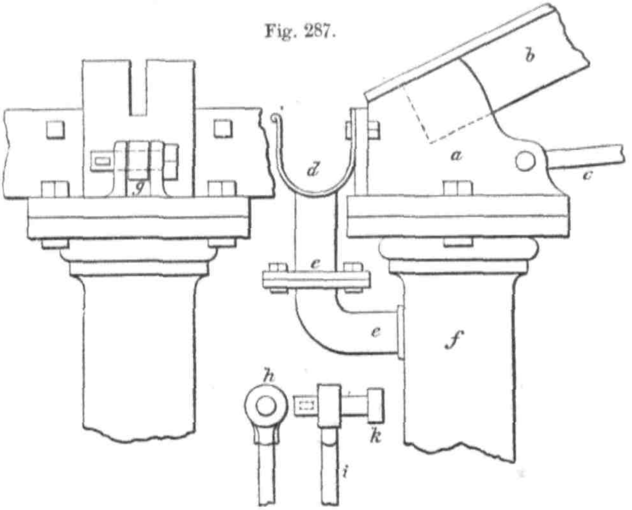
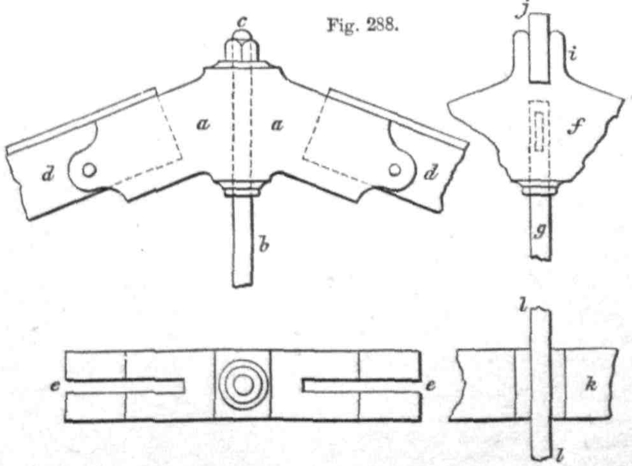
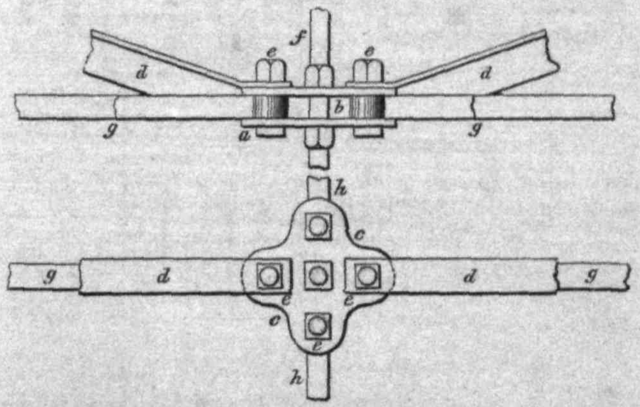


Fig. 288.



gives details of the head, in which the upper ends (*d*, fig. 283) of the rafters are housed: *a a* shoe or head, *b* the tie-rod (*d f* in fig. 283) passing through it, and secured by the nut *c*; *d d* the rafters, *e e* a plan of under side of shoe. Another form is given in same diagram at *f*: the tie-rod *g* passes up a certain part of the shoe only, and is secured by a key or cottar. The upper part is finished as at *i*, forming a groove or recess, in which the ridge-pole *j* is placed: *k* is plan of top, *l l* ridge-pole. Fig. 289 shows details of method of joining the bottom

Fig. 289.



of tie-rod *d f*, tie-rods *e f*, and braces or struts *f g*, fig. 283. Two plates, *a b*, of which a plan is given at *c c*, are employed; the rafters *d d* are secured to these by the bolts and nuts *e e e*; *f* the king-bolt, *g g* the tie-rods: lateral tie-rods *h h* are employed between truss and truss; these run parallel to the walls. Another form of junction is shown in fig. 290. In fig. 291 the junction of upper end of brace or strut (*f g*, fig. 283) with the rafter is shown: *a* end of strut, secured to rafter *b b* by the two plates *c c*. Where a double roof is employed—of which *h*, fig. 283, shows a part of the rafter corresponding to *d c*—a rafter-box for the junction of the two rafters at the top of the central pillar, after the form given in fig. 292, must be employed—*a* the hollow central column or pillar, taking the water from the gutter *b*; *c c* the two rafters; the tie-rods—corresponding to *e f*, fig. 283—may either be

jointed to the rafters *c c* at the points *d d*, or to snugs *e e*; *f* is a side, *g* an edge view of the ends of tie-rod.

Fig. 290.

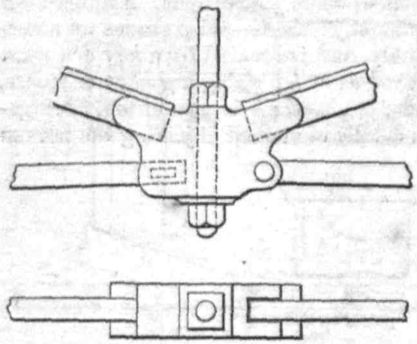
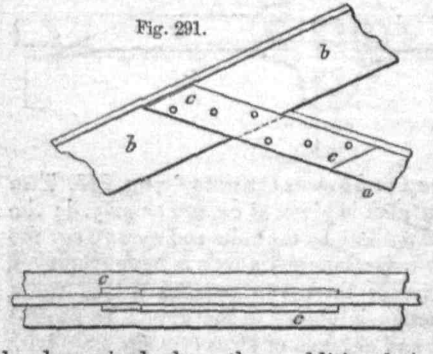


Fig. 293 shows a truss for an iron roof—scale $\frac{5}{16}$ths of an inch to the foot —in which the king-bolt *d f*, fig. 283, is dispensed with, and two struts of cast iron, *a b*, are substituted. In fig. 294 we give at A a side view, and at B a section in line *a b* (A) of the junction of upper end of struts with the rafters at the points *c c*, fig. 293. Fig. 295 shows the foot of strut at points *d d*, fig. 293 : *a*, tie-rod, corresponding to *d d* in fig. 293; *b* tie-rod corresponding to *d e*, *d e*, fig. 293.

Fig. 291.



In some cases additional tie-rods, *d f*, *d f*, fig. 293, are employed. In fig. 295, *c* shows part of the lower termination of one of these; whilst *b* corresponds to tie-rod *d d*, fig. 293. Fig. 296 illustrates the form of rafter-head required where these additional tie-rods are employed: *a* shoe, *b b* rafters, *c d* tie-rods, *e* ridge-pole. Where the tie-rods *d f*, *d f*, fig. 293, are not used, the rafter-head is precisely the same as in fig. 288, only no provision for king-bolt *b* is required to be made.—*Scale of figs.* 293, 294, 295, *and* 296, *in fig.* 284.

In figs. 297 and 298 we give, drawn to a scale of $\frac{1}{8}$th inch to the foot, a plan and section of a *conical roof* for an *octagonal*

Fig. 292.

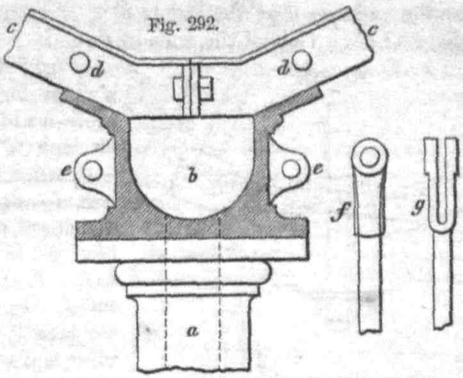


Fig. 293.

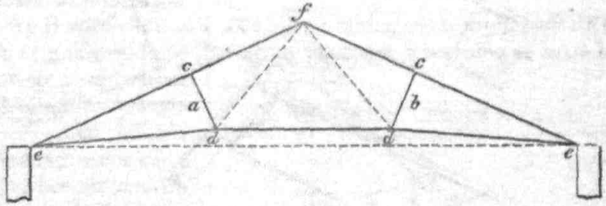


Fig. 294.

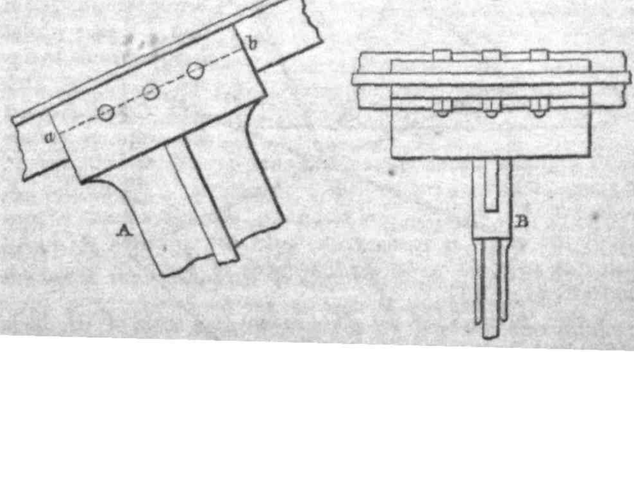


Fig. 295.

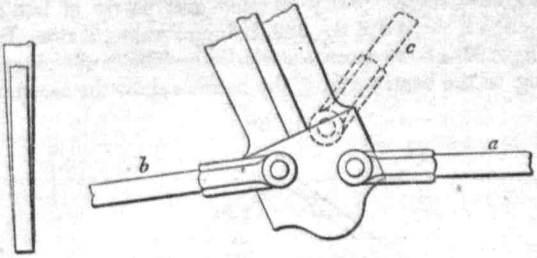


Fig. 296.

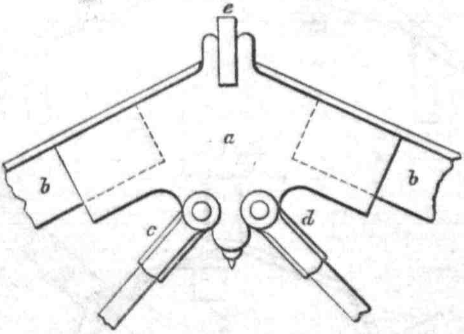
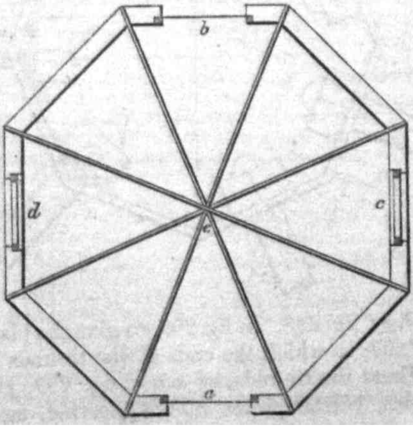


Fig. 297.



building, constructed partly of wood and partly of iron; the parts *a a*, *b b*, *c c*, and *d*, fig. 298, being of wrought iron. In the plan, fig. 297, *a b* are doors, *c d* windows. The double lines converging to the centre *e* from the corners show the assemblage

Fig. 298.

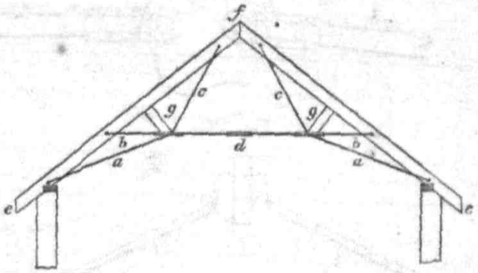
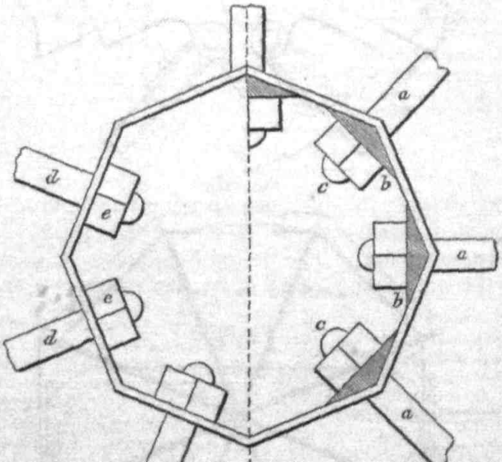


Fig. 299.



of rafters *e f*, *e f*, fig. 298. In fig. 299 we give the plan of central ring *d*, fig. 298, to which the ends of the tie-rods *b b*, *d d* are bolted. Where the tie-rods, as *a a a*, fig. 299, join the ring at the angles, bolster-pieces *b b* are inserted, against which

the nuts *c c* are screwed hard up. Where the tie-rods, as *d d*, join the ring in the centre of its sides, the nuts *e e* butt immediately against these. In fig. 300 we give end of struts *g g*,

Fig. 300.

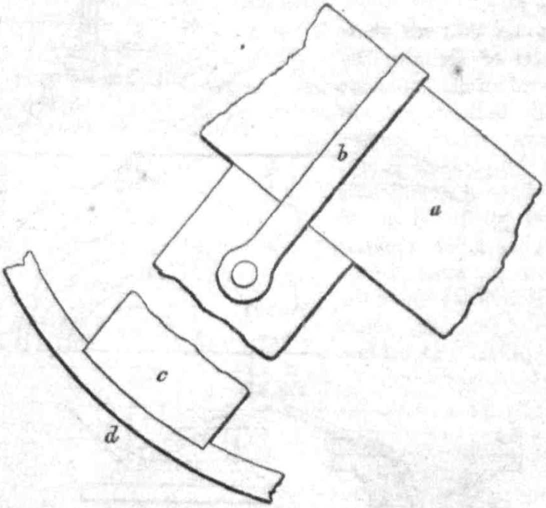
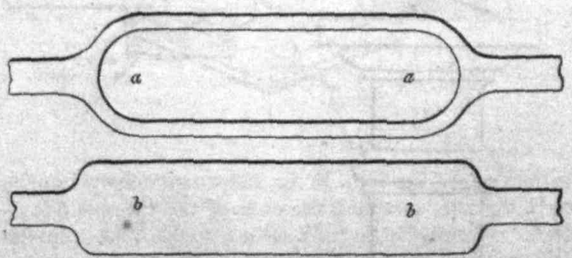


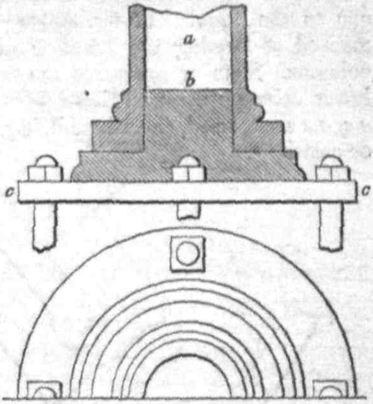
fig. 298, showing its junction with rafter *a* by strap *b*. The end *c* is rounded, and the tie-rod *d*—corresponding to *a c*, *a c*, fig. 298—passes round. The tie-rod *b d* widens out so as to embrace the end of the struts *g g*, fig. 298. Fig. 301 shows the

Fig. 301.



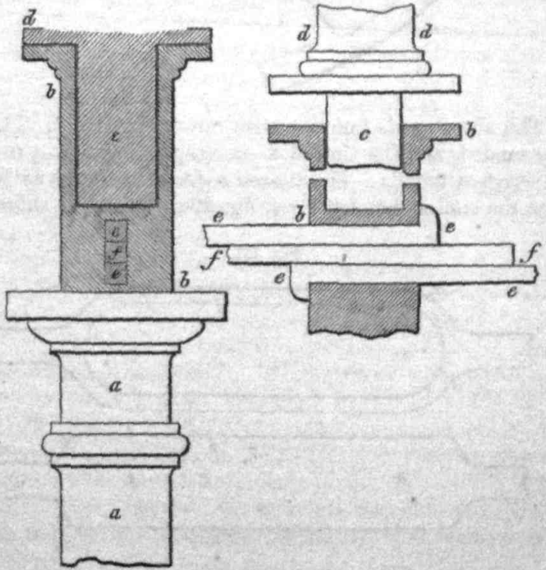
widened part at *a a*. In this part the end of rod *g* is placed, and the tie-rod *a c*, fig. 298, also passes through it: *b b*, fig. 301, is a side view of *a a*.—*Scale of figs.* 299, 300, *and* 301, 2 *inches to the foot.*

Fig. 302.



In fig. 302 we show method of forming the base of iron columns: *a* the hollow part of column, which passes over the projecting part *b* of base *c c*, which is bolted to the stone or brick basement: a plan is shown in same figure. In fig. 303 we show the mode of junction, where one pillar or column

Fig. 303.



rests upon another. The lower column *a a* is continued upwards, as at *b b*, the upper part of which is made hollow to admit the lower part *c* of upper column *d d*. Columns are sometimes braced together by iron tie-rods stretching from one to the other. In fig. 303 we illustrate Mr Fairbairn's method of forming the junction of these tie-rods with the columns. Slots or apertures are made in the part *b b* of the lower column; through these slots the ends of the tie-rods *e e*, *e e* are passed, the whole being tightened up by the key or cottar *f f*.

SECTION TWENTY-FIRST.

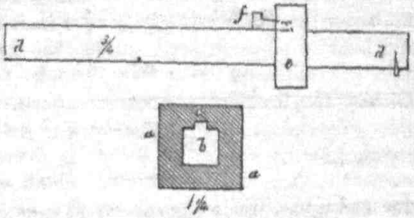
JOINERY TOOLS—MOULDINGS—DOORS—WINDOWS—STAIRCASING.

The distinction between the two operations of Carpentry and Joinery may be simply stated. In the former, the framing and erecting of heavy timbers for the purposes of floors, roofs, partitions, &c., form the principal business; in the latter, the making and fitting up of external and internal furnishings —as door-cases, doors, windows, window-frames, &c.—are the operations to be performed. In both, however, there are many common operations, which differ only in the fact that, for the purposes of joinery, they may be on a smaller scale than when required for those of carpentry. In general, all timbers used for carpentry are left rough as they come from the operation of the saw or the axe; while in joinery, all exterior surfaces are made smooth and uniform by appropriate instruments. The tools required for the simple operations of joinery, to be carried out by the emigrant, may be enumerated as follows: the "ripping-saw," for cutting up heavy planks—the teeth in this are 96 to the foot, or 16 to the two inches; the "hand-saw," for ordinary work, 45 teeth to the foot; the "sash-saw," for cutting fine work, with a brass back—it has 156 teeth to the foot. For cutting dovetails, a small saw, having 180 teeth to the foot, is used. Tenons may be cut out by means of the "sash-saw." A long, thin, and narrow saw, termed a "keyhole saw," having no back, and useful for cutting out holes in wood: a size as follows will be useful—length 12 inches, breadth at point $\frac{1}{4}$ inch or $\frac{3}{16}$ths, breadth at handle $\frac{3}{4}$ inch. The planes used in joinery are very numerous. The "jack-plane" is used for taking the rough surface off the timber to be smoothed in surface. It is used by taking

off as much as can be taken in by one arm-stretch—the workman beginning at the near side of the plank, and gradually taking off the rough across the breadth of the plank. On a part of the plank within arm-reach being done, the workman moves farther along, until the whole surface is acted upon. To bring this surface properly smooth, and to a level, a larger and heavier plane is used, termed the "trying-plane." Shavings are taken off with this the whole length of the plank. To test the level of the surface, a straight-edge (that is, a piece of wood about 18 inches long, ½ inch thick, and 2 inches broad, having one edge perfectly true and square) is laid across the face, and the workman looks along the plank, where the straight-edge is lying on it: all inequalities are then easily observed, and are to be reduced by the plane. As the edges of the plane are generally accurately cut, the workman sometimes tests the "truth" of the surface of the work by laying the edge of the under side of the plane across the face of the plank. The "hand or smoothing plane" is used for giving a final truth and smoothness to the work, and for finishing up small work. It is used with both hands in some operations—with only one in others. It is much shorter than the two others, being about 7 inches—the length of jack-plane being 18, and that of the trying-plane 22 inches. For making varieties of mouldings, "moulding-planes" are used; but as the operations are rather difficult, and not much required for ordinary work, we do not here describe them. The emigrant should, however, provide himself with a "rebate plane," for forming rebates on the edges of planks, framing, &c. The nature of a rebate we have already described. The "plough" for sinking a "groove," and the plane for making the "tongue," are also required. Chisels are numerous; but the "paring-chisel," of various sizes, from ¼ inch in breadth to 1 inch, will be all that is necessary. The "mortise-chisel" will also be necessary. "Gouges" are circular chisels, and are used for making hollows: they are of various sizes. Small holes are made by "brad-awls" and "gimlets"; they are of various sizes. Circular holes, of large diameter, are made by means of a "brace" and "bit"; the bits are of various sizes. Screwdrivers of various sizes will be required; as also "hammer," "pincers," or "pliers." To assist the workman in marking off a line on a plank, parallel to the

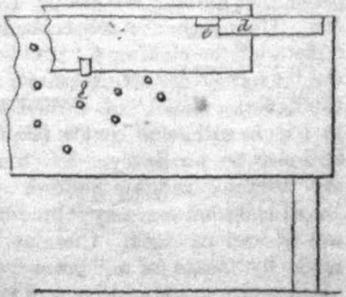
edge, and at any distance required, an instrument termed the "gauge" is necessary. This may be made by the workman emigrant, according to the drawing in fig. 304. A piece of hard wood *d d*, some 6 or 9 inches long, is provided, and properly squared up; at one end, within $\frac{1}{2}$ inch or so, a nail is driven so as to project about $\frac{1}{8}$ inch. This is sharpened to an edge. A piece of wood, *a a*, $1\frac{1}{4}$ inch square and 1 inch thick, is provided with an aperture *b*, $\frac{3}{4}$ square, having on one side a small mortised hole *c* cut in it, about $\frac{1}{4}$ or $\frac{3}{8}$ broad and deep. This piece *a a* is passed over *d d*, as *e*, and can be secured at any part by means of a small wedge *f*, passed into and driven up the mortised hole *e*. By means of a rule, the distance between the edge of the nail and face of *e* may be arranged as required; and by putting the face of *e* to the edge of plank, and drawing it along, the edge of the nail will draw a line on the face of the plank, at a distance from its edge, corresponding to the distance of the nail from face of *e*.

Fig. 304.



For the purpose of assisting the workman in his various operations, the "bench" is an indispensable requisite. This may be described as a species of framed table, having a level top, and a sideboard perforated with holes, about 1 inch diameter, as in fig. 305. It is provided with a wooden closing-jaw and screw at one end, by which the plank to be operated upon is firmly fastened. As the screw, however, may not be easily made or obtained by the emigrant, we show in fig. 306 a con-

Fig. 305.



trivance which will serve in its place: *a a* is the top of table; *e* a horizontal piece of timber projecting from side-board of bench some 12 or 14 inches, and firmly fastened at one end to the frame of bench: it is about 6 inches broad. An irregular-shaped piece *d*, about 1 inch thick, is nailed on to the top of *e*, at its outer end, forming an angular space, into which a wooden wedge, 1 inch thick, is driven. This holds the plank or other work *f* to be operated upon, while the other end is supported by the bench-pin *g*, which is passed into one of the numerous holes made in the side-board (see fig. 305). The bench-pin *h* is about 7 inches long up to the shoulder, and is cut out of one piece of wood. For the convenience of sawing up timber, &c., trestles or saw-benches, *a d*, fig. 307, are used, on which to place the plank *b b* while being sawn. The dotted figure shows the side elevation of one trestle, the others being shown at the ends.—*The scale of this diagram is ¼ inch to the foot.*

Fig. 306.

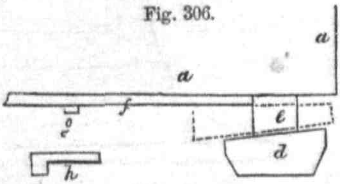
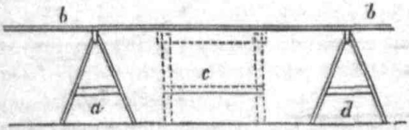


Fig. 307.



Mouldings.—Fig. 308 is the fillet; fig. 309 the astragal, or bead; fig. 310 the quirk-bead, where the face of the bead *a* is flush with the part *b*. Fig. 311 is a double-quirk, or return-bead. Where the bead projects from the surface it is called a "cock-bead," as in fig. 312. This is also called the "torus" moulding.

Fig. 308. Fig. 309.

Fig. 310. Fig. 311.

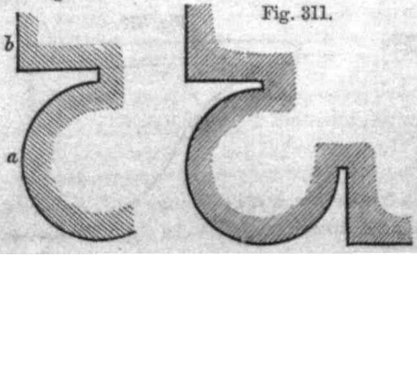


Fig. 313 is the Roman, and fig. 314 the Grecian "scotia." Fig. 315 is the Roman, and fig. 316 the Grecian "ovolo."

Fig. 312.

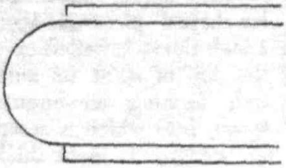


Fig. 313.

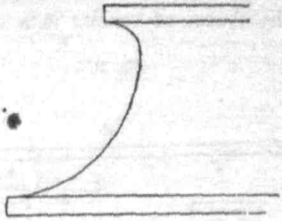


Fig. 314.

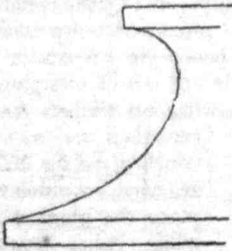


Fig. 315.

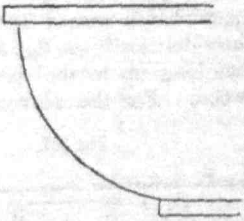


Fig. 316.

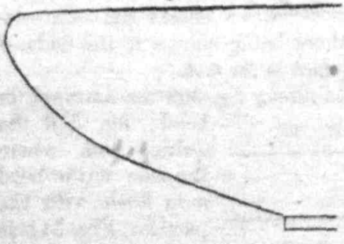


Fig. 317.

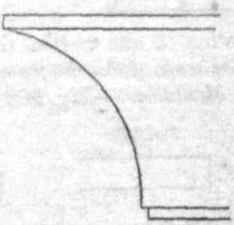


Fig. 318.

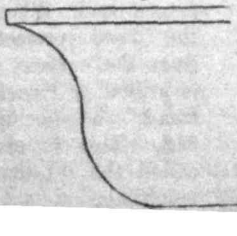


Fig. 319.

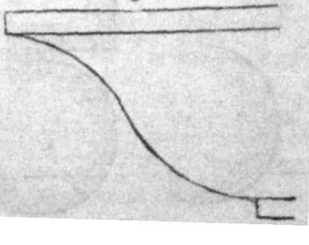


Fig. 320.

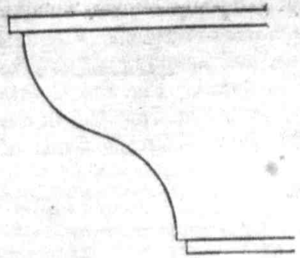


Fig. 321.

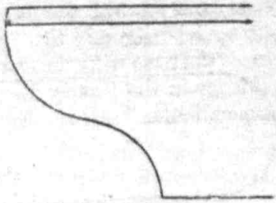


Fig. 322.

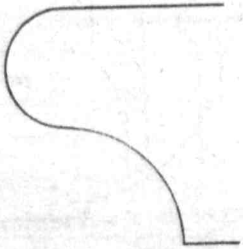


Fig. 323.

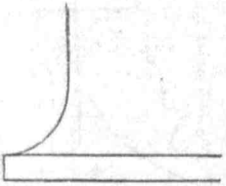


Fig. 324.

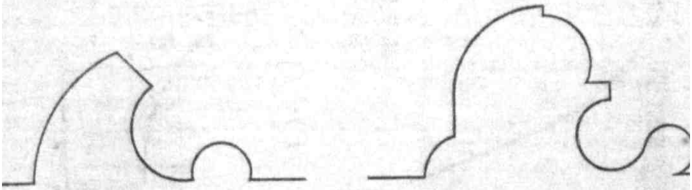


Fig. 325.

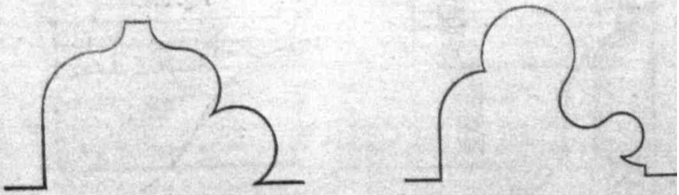
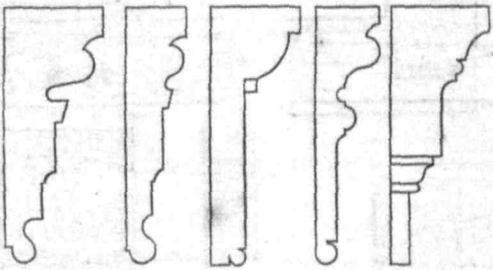


Fig. 317 is the Roman "cavetto," or hollow. Fig. 318 the Roman, and fig. 319 the Grecian "cyma-recta." Fig. 320 the Roman, and fig. 321 the Grecian "cyma-reversa." Fig. 322 the "ogee;" fig. 323 the "congee," or "apophygee," used to connect the base with the shaft of a column. Fig. 324, Gothic mouldings in the "early English" style; and fig. 325 in the "perpendicular" style. Fig. 326 shows different forms of

Fig. 326.



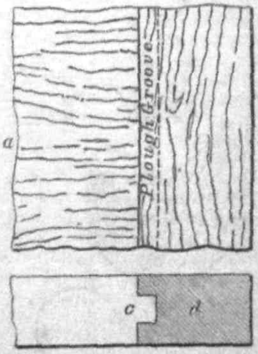
"architraves" for the interior lining of doors and windows. Figs. 327 and 328 sections of "room-skirtings."

Joints.—Boards, as *a b*, fig. 329, are joined together, the

Fig. 327.

Fig. 328.

Fig. 329.



fibres of one piece, *b*—which is termed the "clamp"—being at right angles to the other, *a*. The two are joined by the feather *c* passing into the plough-groove in the clamp *d*. In fig. 330 we show various modes of joining timbers at right

Fig. 330.

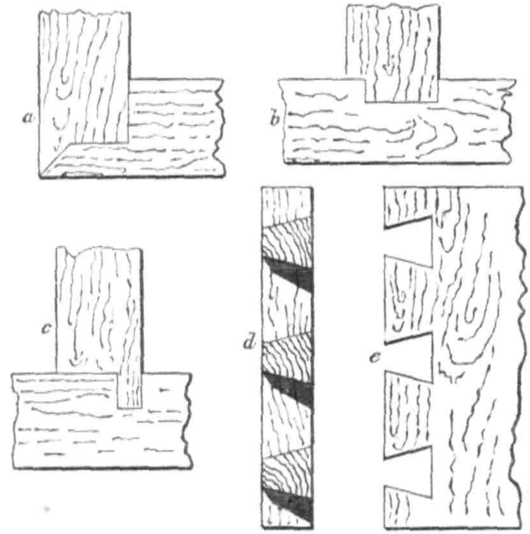


Fig. 331.

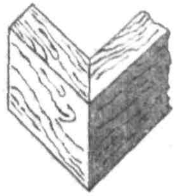
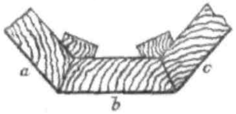


Fig. 332.



angles, as at *a b* and *c*; and at *d* and *e*, the joint known as the "dovetail." Fig. 331 shows the "mitre-joint." Where pieces of wood are glued to the interior angles of parts, as *a b c*, fig. 332, they are termed "blockings." Where pieces of wood are let into the back of a board to prevent the widths of which it is composed warping, they are termed "keys," as at *a*, fig. 333.

Fig. 333.

Doors—Windows.—In fig. 334 we illustrate a braced and ledged door: *a a* boards, *b b b* ledges, *c c* braces. In fig. 335 we give a drawing of a framed door: *a a* styles, *b* bottom rail, *c* middle rail, *d* top rail. Fig. 336 is a four-panel door: *a* is the middle or lock rail, *b* the bottom rail, *c* the top rail, *d d* muntins; the style *e e*, to which the hinges are fixed, is called the "hanging style."

Fig. 334.

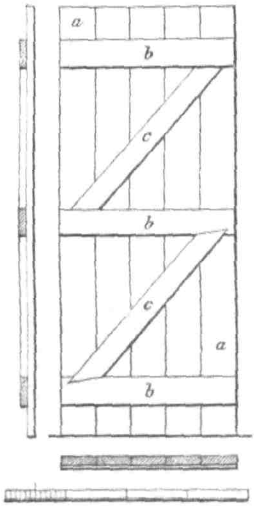


Fig. 335.

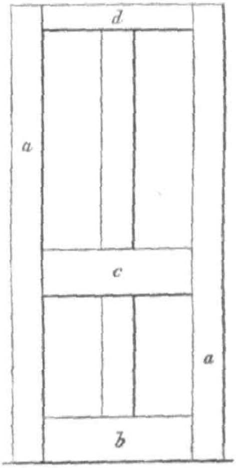


Fig. 337 is a sash door, with window *a a*.—*Scale of figs.* 335, 336, *and* 337, *in fig.* 334.

Additional remarks on the construction of Doors will be found at page 216.

Fig. 336.

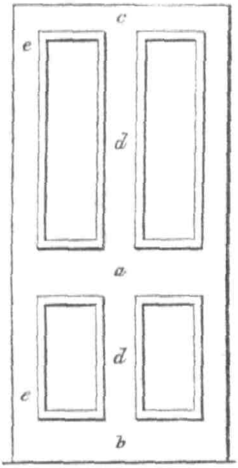
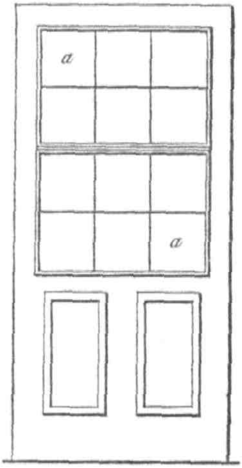


Fig. 337.



Windows.—In fig. 338 we illustrate a common sash window, and in fig. 339 a French casement window: in this the part *a a* is fixed, while the parts *b* and *c* open right and left, like the leaves of a folding-door.

In fig. 340 we give a sketch showing the arrangement of the shutters of a sash-window: *a a b d e* are termed the "casings" of the sash-frame; *a a* the pulley-piece, on which the pulleys are fixed, over which the cords pass which sustain the sash-weights *b*. The inside lining and bead are at *e c*; outside lining *d*, back lining *b*; *f* the architrave of the shutter-box, which contains the folding-shutters *g g′*, *g g′*. The back-flaps *a a*, fig. 341, are additional pieces attached to the front shutter when that is not broad enough to cover the window.

Fig. 338.

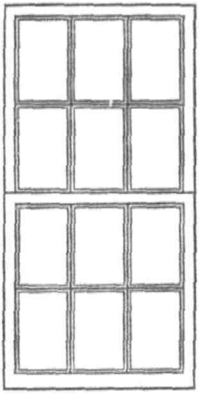


Fig. 340.

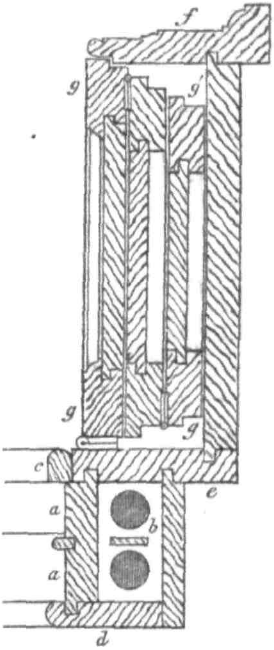


Fig. 339.

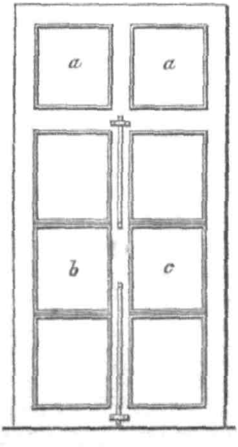
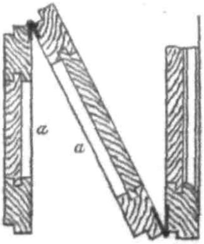


Fig. 341.



We now proceed to describe a few methods of making windows and doors of a simpler construction than those we have now illustrated, which may be of use to either the emi-

grant or the small farmer in this country. In fig. 342 we give a diagram of the framing for a window 4 feet high—that is, between upper and under side of lintels *a a*, *a a*—and 2 feet broad between inner side of side-posts *b b*, *b b*. Part of the length of side-posts is broken off to save room. The lintels *a a*, *a a* are 4 by 3; the side-posts, same size, are attached to these by any of the joints already described; a centre rail *c c*, 4 by 2, divides the window into two. Fig. 343 shows the plan of this, where the angular form of wall *o o* is shown, commencing at upper side of lower lintel *a a*, fig. 342, and terminating at upper side of upper lintel *a a*. The window-sill, in the inside of room, is formed by placing a piece of boarding, inch thick, in the space between *o o* at *m*, and projecting over inside wall about $\frac{3}{4}$ inch. An exterior sill may be made by nailing to outside of under lintel *a a a a*, a piece of timber 3 inches square—the upper side sloping, and under side throated. On the supposition that the emigrant, on first settling, cannot obtain glass, we show a simple frame in fig. 344, adapted to transparent waterproof calico. In fig. 345, the manner of putting the frame together with half-lap joints, *c c*, corresponds to the sides *a a*, *a a*, fig. 344, and *n n* to the ends *b b*; *s s t* show the two as placed together. In fig. 344, *e e*, *e e* are leather hinges,

Fig. 342.

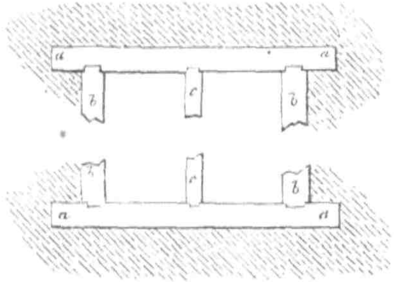


Fig. 343.

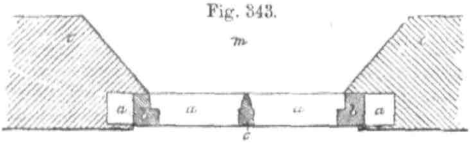
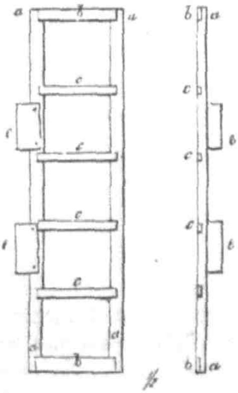


Fig. 344.



one side nailed to the frame, and the other to the side-posts *b b*, fig. 343; *c c c c* are the astragals, placed at equal distances, on which the calico is fastened with small nails. A side view of the frame is given. The calico should be nailed inside the frame. Instead of calico, thin sheet gutta-percha would be eligible. The calico may be made transparent by painting it with boiled linseed-oil. Instead of forming the rebate on the side-posts of doors, windows, &c. (as in fig. 343, at *b*), a thin piece of wood (as *a*, fig. 346) may be nailed on face of side-post or lintel *b*, as much shorter or narrower as the depth of rebate required. The thickness of *c* may be ½ inch or ¾ inch at most. In the simple kind of window now described, each half of the window opens like a door, and is termed a French window. In fig. 347 we give the drawing of a sash window, the upper half *c* of which is fixed, the lower being movable—that is, capable of being lifted up. The lower movable sash is, however, not balanced by sash-weights, but is retained in its place by a simple catch, or a piece of wood, at any desired height. The construction of a balanced sash is of too complicated a kind to be attempted by any but an experienced workman. The sketch to the left is a section (vertical), that to the right being an elevation: *a a a a* is the framing, 5 by 3; *á á á á* the wall, 14 inches thick; *c* the upper sash, firmly nailed to the fram-

Fig. 345.

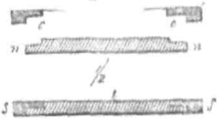


Fig. 346.

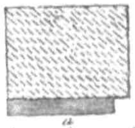
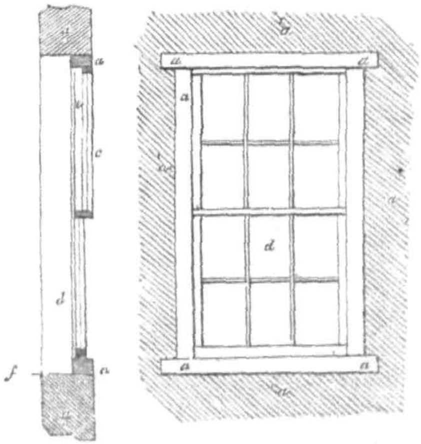
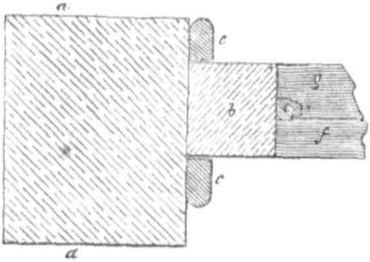


Fig. 347.



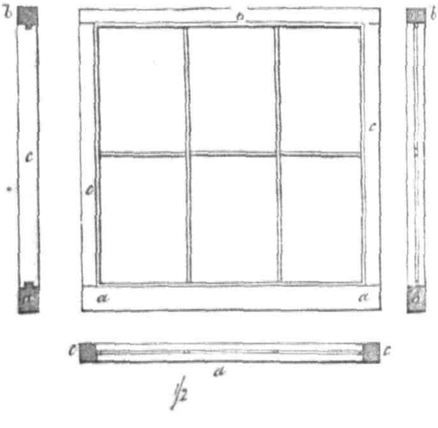
ing ; *d* the lower movable sash, which slides up into the space *e*. The lower sash *d* is prevented from coming out of its place by two bars *c c* (fig. 348), ½ inch thick, and inch wide, nailed to the inside and outside of side-posts *a a*. The outer one is only continued from bottom lintel up to the under side of upper sash; the inner one, being carried up to the under side of upper lintel. In fig. 348, *b* is the side of sash-frame *c*, fig. 347; *e* the rebated astragal, *f* the glass, *g* the bottom rail of sash-frame *c*, fig. 347.

Fig. 348.



The dimensions of this window are, 3 feet 4 by 6 feet 5; each sash is divided into six panes, 12 by 17. In fig. 349 we give drawings of the lower sash, drawn to a scale of ½ inch to the foot. The lower rail, *a a*, is 3 by 2; the upper, *b*, 2 by 2, as also the side ones *c c*. The sketch to the right shows position of top and bottom rail, and astragal for sustaining the glass; that to the left, an end view of sash; that to the bottom, a plan.

Fig. 349.



A method of making the astragals, for sustaining the glass in windows, is shown in fig. 350, which is a cross section of one. A piece of wood any desired length (they may be made in long lengths, and cut as desired) is planed up to 1¼ inch broad by ½ inch thick; a rebate is made on both sides, as *b*, ¼ inch

deep, and of breadth so as to leave the front *a* ¼ inch broad. The sides *c c* are ½ inch broad, and the other portion is tapered off to a little more than ⅛. The glass is fastened in the rebates *b*, and secured with putty, filling up the angle. The part *a* is outside, *d* in the interior of the room. In fig. 351 the manner of joining the astragals together is shown: *a a* corresponds to the vertical lengths in fig. 349, *b b* to the cross ones. They may be joined by a dovetail, or other joint, or nailed together. The dotted lines in fig. 350 show the position of an astragal at right angles to *a d*. In fig. 352 we give a diagram illustrative of the arrangement of another form of sliding window: in this instance the window is pushed from side to side laterally, instead of lifted vertically, as in fig. 347. Let *a b c d* be the opening of window in inside of frame, or in the wall; *h h* the wall of room; below the window fix (to wood bricks fixed in the wall) a horizontal timber *e e*, 4½ inches by 4 feet, having nailed on its upper side

Fig. 350.

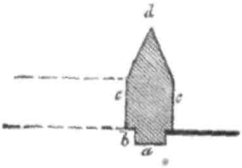


Fig. 351.

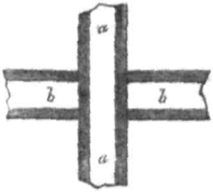
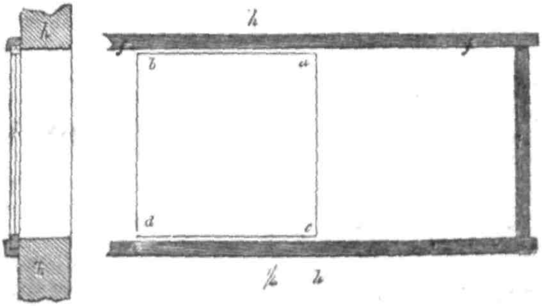


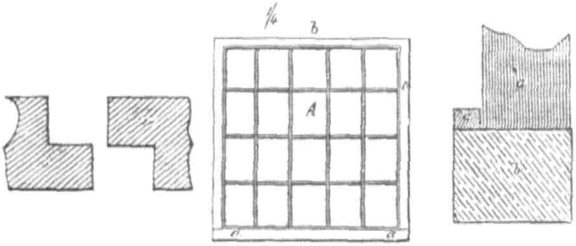
Fig. 352.



a piece c, fig. 353, ½ inch square; similar to this fix above the window another horizontal slide *f f*, but having its piece, as c, fig. 353, fixed on the lower edge;—there will thus be at

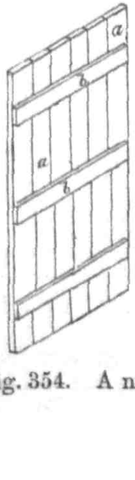
upper and under sides of window, and extending beyond it on both sides (or one, as the window is desired to be moved on both sides or one only), two slides, in which the sash-frame *a b c d*, fig. 352, can be moved or pushed along. To facilitate its being moved along, the two projecting handles may be attached to the sash-frame inside. The upright *g*, fig. 352, limits the extent to which the window can be opened, or slid along *e e*, *f f*. In the diagram we have represented the horizontal bars *e e*, *f f* as being broken off. If the window is required to be capable of moving either to right or left of window-opening, they will extend to an equal distance on both sides: if the window only is to move to one side, a vertical post similar to *g* will be placed close to the edge of window, at side opposite to that at which *g* in the diagram is

Fig. 353.



placed. In fig. 353, *A* is the sash-frame, 4 feet square, inside measurement, the scantling of rails being same as in fig. 349. It is divided into 16 squares, 12 inches by 9. The diagram to the right represents the under rail *b*, corresponding to *e e* in fig. 352, to a larger scale of ¼ inch to the *inch*; *a a* is the bottom rail of sash. Instead of making the window in one size, it may be divided into two, the inner rails of sash-frame being rebated, as in the sketch to the left, so that, when closed together, they will form a water-tight joint.

Fig. 354.



Doors.—We here make some additional remarks on the construction of doors. These are of two descriptions,—ledged and framed. A ledged door is shown in fig. 354. A number of boards *a a*, of length equal to length

of space of door-way, and of number and breadth sufficient to make up breadth of doorway, are put close together, and secured by cross pieces, or ledges, *b b*: the long boards *a a*, in superior work, are tongued and grooved. Ledged doors, where the doorways are circular-headed, may be finished in the interior, as in fig. 355. In both of these forms the interior views are shown; the exterior are quite plain. The manner of constructing a framed door will be gathered from fig. 356, where the height is 6 feet 3 inches: *a a*, *b b* are the side styles, each 3½ inches wide, and beaded at the edges if considered necessary; *c c* the centre style, same breadth as *b b*; the top rail *d*, 3½ inches, the middle rail *e*, 9½ inches, and the bottom rail *f*, 9½ inches wide, are mortised into the side styles *a a*, *b b*; the centre style *c* is mortised into the top and middle rail, and to the middle and bottom rail. The spaces marked with crosses are filled in with panels, let into grooves made in the edges of the styles and rails. All doors close against linings, which may be formed by cutting a rebate, as *b*, in the door-posts *a a*, fig. 357; or by nailing on both door-posts in the inside, a piece some half-inch thick, and an inch less in breadth than the breadth of door-post, as in the diagram. The space *b* should be a little wider than thickness of door (1 inch for ledged, and 1¼ inch for framed), in order to admit of inside of door coming flush with the inside of door-post when closed.

Fig. 355.

Fig. 356.

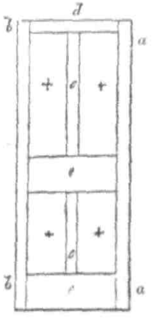
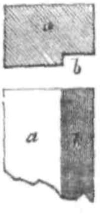


Fig. 357.



In now concluding this department, we give a few diagrams illustrative of the method of fitting up useful

adjuncts in a house, as shelves, &c. Let *b*, fig. 358, be the wall or partition against which a shelf is to be fixed : *a* is the shelf, made out of $\frac{1}{2}$ or $\frac{3}{4}$ inch stuff, planed up to any desired breadth, and supported at intervals, say of 3 feet, on cross-pieces *c*, made out of pieces of small saplings ; or the shelf *c*, fig. 359, may be supported on brackets of form as in the diagram, or cut out as in the dotted lines to make it more ornamental, and nailed to the wall *a a* : the thickness of brackets may be equal to that of shelf *c*. Shelves can be very conveniently put up in corners, thus using room which, to a certain extent, is useless. In this case ledges, made of fir $\frac{3}{4}$ or inch thick, 2 inches broad, and say 15 inches long, and nailed on the walls at any convenient height, to meet in the corners with a board $\frac{3}{4}$ inch thick, cut so as to go into the corner, 15 inches long on the side, and cut round at the outer edge, will make a very convenient shelf. Hanging-shelves for books, &c., may be useful. The method of constructing these may be gathered from fig. 360, where *a b c* are the shelves, of any convenient length and width, supported by strong cord passed through holes made at the four corners of each shelf, and gathered into one at the point of suspension *d* : a knot is made in the cords, immediately beneath each shelf on which it rests.

Fig. 358.

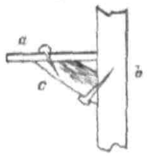


Fig. 359.

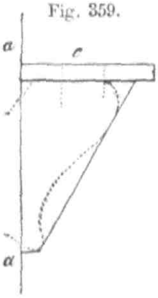
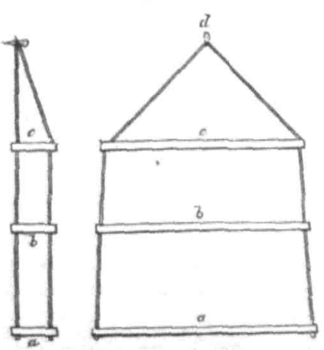


Fig. 360.



Cupboard drawers, fitted up at the recess on one or both sides of fireplace, will be useful. The method of making the drawer portion will be seen from figs. 361, 362, and 363. In fig. 361 (the scale is 1 inch), *c c b* is the drawer, of which there may be two in each tier, with two tiers. The top *h*, fig.

362, is of length and width equal to the size of recess in which the drawers are to be placed; the sides *c c*, of height from the ground sufficient to allow of two tiers similar to *a a*; and a bottom bar, corresponding to *b*, half as broad again as *b*, the breadth of *c c* = 2½ inches; *b* same; the width of openings *a a* exactly equal to width of drawer *c c*, fig. 361 = 14½ inches, and the depth from under side of *b*, fig. 362, to upper side of cross ledge *e e*, equal to depth of drawer, 5 inches. In fig. 361, the bottom of drawer is some half inch up the sides: this is to form two sliding surfaces, which slide on the parts *a a*, fig. 363. This diagram is a plan of fig. 362—showing the side *c c*, the central bar *d*, the ledge *e e*. The distance from bar *e e* to *f f* is equal to length of drawer, or 16 inches; the bar *d* is inch wide; and the parts *a a*, on each side of *d*, about the same.

Fig. 361.

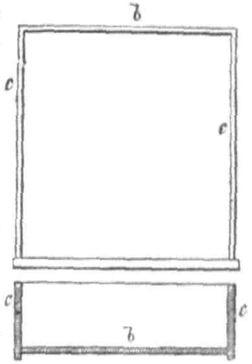
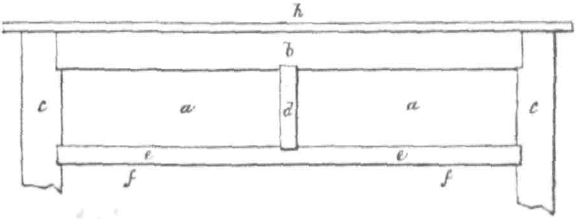


Fig. 362.

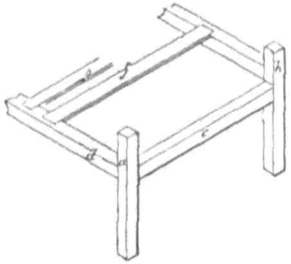


In the centre of fig. 363 a cross section of *a a d* is given: the lower edges of the sides of drawer *c c*, fig. 361, slide on the parts *a a*. The drawings, it is hoped, are so explanatory in themselves, that further description is deemed unnecessary. The top *h*, fig. 362, may be left exposed, so as to form a table or shelf.

A centre table may be simply formed, by joining boards *a a*, fig. 364, of any required length, and supporting it on crosses, one at each end, as *b b*, *c c*. To make this portable, the arms *b b*, *c c* may be jointed at the centre by passing a pin or

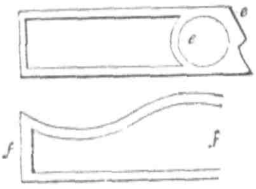
The timbers of a settle bed are shown in fig. 370, the horizontal timbers *d c* being mortised into the uprights *a b*;

Fig. 370.



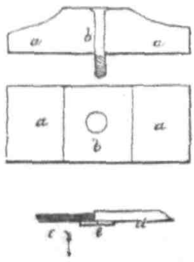
the spars *f g*, on which the mattress is supported, let into recesses equal in breadth and depth to those of the spars, giving a bearing of at least $\frac{3}{4}$ inch. The uprights *a b* may be 2 feet 9 high, and 3 inches square; *c d* same size, and not less than 6 feet 6 in length. This form of bed may be made rather ornamental—a desideratum always to be considered where great extra expense is not incurred in carrying it out. By attaching a foot-board, as *f f*, and a head-board *e e*, fig. 371, a pole, some $3\frac{1}{2}$ inches at bottom, $2\frac{1}{2}$ at top, and 1 thick,

Fig. 371.



may be fastened at the back of the head-board in the centre: its length should be about 6 feet. If, at the upper extremity of this, a short pole, some $1\frac{1}{2}$ inch diameter and 24 inches long, projects at right angles, and parallel with the bed, a curtain may be supported on it; and which, if brought down on each side, over the sides of the bed, to near the ground, will give the whole a handsome and graceful appearance—and this obtained at a very trifling additional outlay.

Fig. 372.



The inner door of a house may be made fast by adopting the simple contrivance of a bolt, as *a b a* in fig. 372, turning on a screw-nail *b*, as a centre, let into the inner side of the door-post. The lower diagram shows its application: *c* the door, *e* the bolt, *d* the side-post, or partition, to which the bolt is fastened. So long as the bolt is turned across the closed door, the latter cannot be opened from the outside, unless the bolt gives way. This bolt may be used for keeping cupboard doors shut, it being fastened on

the outside. Fig. 373 shows another form of bolt, for outer doors, barn doors, &c.: *a a* is the side-post or wall; a bent iron staple *c* is fastened to the wall, as shown in the front view. The bolt is formed of a piece of wood *c b*, the breadth and thickness of the aperture *c*, but rather less, to admit of its going easily in and out. A narrow slot or opening is made through and through the bolt, that is, forming an aperture from one side to another,

Fig. 373.

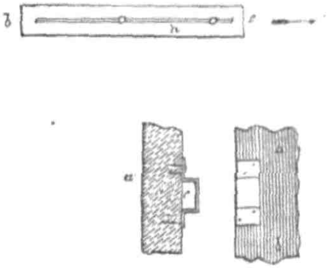
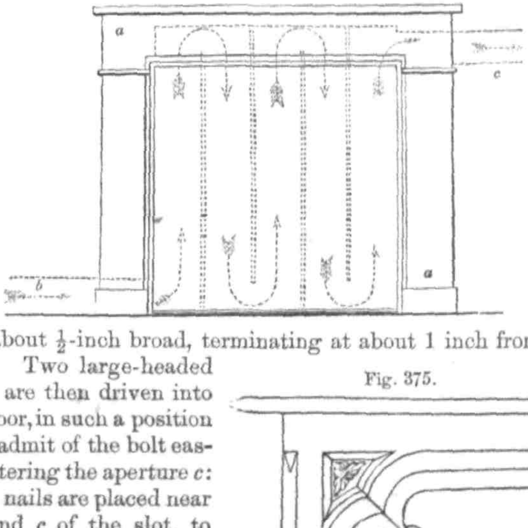
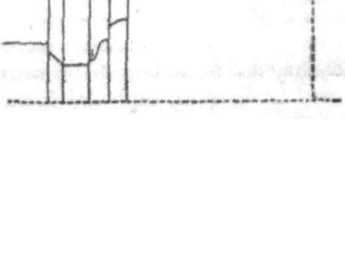


Fig. 374.



and about ½-inch broad, terminating at about 1 inch from the ends. Two large-headed nails are then driven into the door, in such a position as to admit of the bolt easily entering the aperture *c*: these nails are placed near the end *c* of the slot, to admit of the bolt going a certain length in the direction of the arrow: the nails serve also as guides.

Fig. 375.

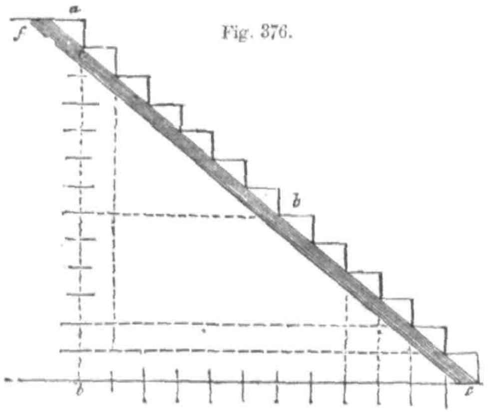


Instead of fire-openings presenting the appearance

of mere apertures, they may be rendered ornamental at a small cost, by attaching to them designs made of timber, as in figs. 374 and 375. The design in fig. 374 is suitable for kitchen, in 375 for sitting-rooms.

We now come to the construction of Stairs. This branch of house construction is one of considerable difficulty, especially in their laying out. We shall endeavour to explain simple methods as concisely as possible. There are two limits of space to be considered in the laying out of stairs—these are, the height from the upper surface of the lowest floor to that of the upper, as the height from *b* to *a*, fig. 376;

Fig. 376.



next, the horizontal distance between the outer edge of the step at the top, as *a*, to that of the lower one at *c*. The part of a step on which the foot rests in ascending or descending is termed the "tread," and for cottages a generally received breadth for this is 9 inches; the vertical part of a step, as *a c*, is called the "riser," and the height may be averaged at 7½ inches. The vertical height *a b*, from one floor to another, being carefully ascertained—suppose it to be 97½ inches, or 8 feet 1½, and the height of riser to be 7½—97½ divided by 7½ lengths will give 13, the number of risers in the stair as in fig. 376. Now, supposing the horizontal distance *b c* to be accurately ascertained to be 9 feet, or 108

inches, the tread being 9 inches, this will give 12 treads,—(the number of treads in a stair is always one less than the number of risers, as the floor of the upper story forms the last tread). To make the stairs according to our simple proposed plan, the next operation is to provide two lengths of timber, 4 inches by 3, dropping a perpendicular line from *a* to *e*, and making *a e* 7½ inches, the height of a riser: place the timbers one on each wall as *c c*, on the walls *a a*, *b b*, fig. 377, one end abutting on the lower floor at *c*, fig. 376, and the other beneath the floor at *f*, in such a position that the upper edge of the inclined timbers may coincide with the points *c* and *e*. The inclined pieces so placed may rest on wooden nogs, 3 inches square, placed into the wall, and projecting some 3 or 4 inches. Take pieces of squared timber, *a b c d*, fig. 378, the side *a b* being 7½ inches, and the side *a d* 9 inches, the length of the timbers being equal to the distance between walls *a a*, *b b*, fig. 377. Divide each timber into two parts by a line *a c*, thus making out of each piece two triangular pieces, as *a e f*, fig. 379. Let *a b c d*, fig. 379, represent the inclined timber *c f* in fig. 376; the triangular piece *a e f* is laid on in the manner shown in the drawing, and firmly spiked at each end to the inclined pieces; the next piece, *f g c*, is in like manner laid on and fastened; and proceeding this way, to the top, a series of steps will be made, having a tread of 9 inches and a rise of 7½. Fig. 377 is a front elevation of fig. 376, showing the distance between the walls and the rise of steps. We now proceed to explain another way of laying out the positions of the treads and risers, on what are termed "string" or "carriage" boards—as *a b c d*, fig. 380, where *e f g h* represent the mortises made in the face of the board *a b c d*, and *e g h i* those for the treads, and into which the ends of the boards, 1 inch thick, are passed, forming the

Fig. 377.

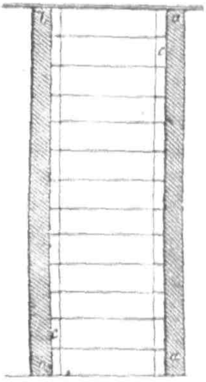
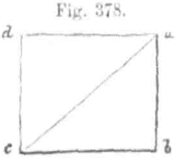


Fig. 378.



"risers" and "treads" respectively. Instead of mortising them, the risers may be merely nailed at each end to the carriage-boards, the treads being nailed on the risers. The dimensions of the carriage-board, where the risers are $7\frac{1}{2}$ and the treads 9, may be 9 by $1\frac{1}{4}$. If the under side of steps is to be covered in with lath and plaster, 4 inches should be added to the above breadth. Having duly ascertained the vertical and horizontal heights, proportioned the rise and tread, and ascertained their number, procure a triangular board *a b c*, fig. 381—the sides *a b*, *b c*, each 12 inches or so, and about $\frac{7}{8}$ths thick—from *b* mark off

Fig. 379.

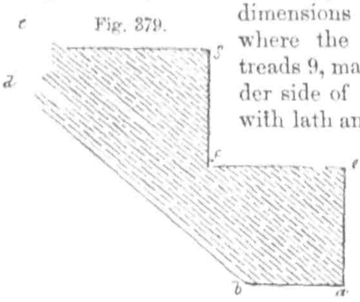


Fig. 380.

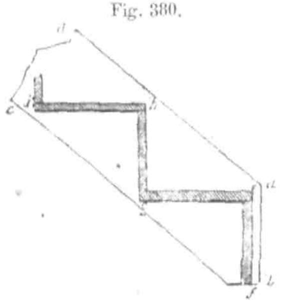
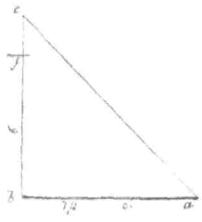
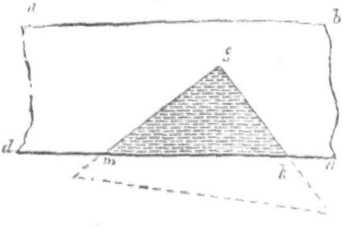


Fig. 381.



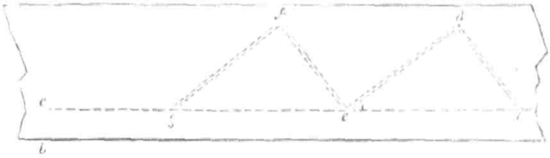
on *b a* an extent of $7\frac{1}{2}$ inches (or whatever dimensions the riser is to be), and from *b* to *f* on *b c*, equal to 9 inches (or the size of tread). Procure a piece of timber *a b c d*, fig. 382, about 1 inch thick, and square up one side *a d*; take the triangular piece, in fig. 381, and placing the point *o* (denoting the extent of $7\frac{1}{2}$ inches from *b*) at any point in the face *a d*, as at *h*, and the

Fig. 382.



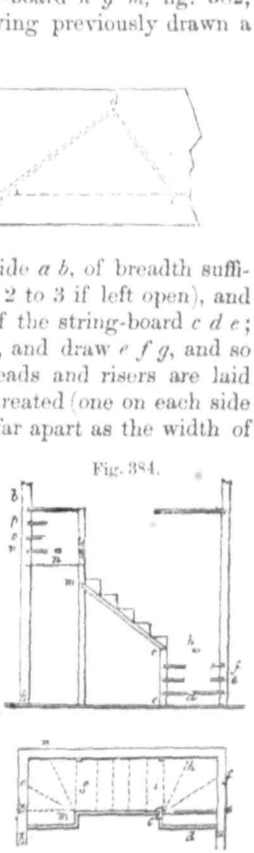
point *f* (denoting the extent of 9 inches from *b*) to meet the line *a d*, mark round, with a sharp point or pencil, *h g*, *g m*, and cut out the piece *h g m*, as shown by the crossed lines; square the edges of this—it will form the "pitch-board" by which to mark the position of treads and risers on the string-board. Having obtained the timber for the string-board of proper dimensions, place the pitch-board *h g m*, fig. 382, with the point *h* at *c*, fig. 383 (having previously drawn a

Fig. 383.



gauge line *c c* from the squared-up side *a b*, of breadth sufficient for plastering 4 or 5 inches, or 2 to 3 if left open), and the point *m* at *e*; draw in the face of the string-board *c d e*; next place the end *h* at *e*, and *m* at *g*, and draw *e f g*, and so on until the requisite number of treads and risers are laid down. The two string-boards thus treated (one on each side of the staircase) are to be placed as far apart as the width of stair; and the boards forming treads, 9 inches wide, and those forming risers, 7½ deep, are to be nailed at the ends or mortised as described in fig. 380—the risers being nailed, &c., to the lines corresponding to *c d*, *e f*, and the treads on the lines *d e*, *f g*. When the stairs, thus formed, are placed in their position between the walls *a a*, *b b*, fig. 377, the treads *d e*, *f g* will be horizontal, and the risers *c d*, *e f* vertical.

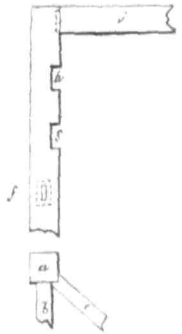
Fig. 384.



We shall next describe the method of making platform stairs, the plan of which is shown in fig. 384. The upper diagram of fig. 384 is a front elevation, *a b b* being the partition walls; a post *c c*, 4 by 4, and 30 inches high, and another, *m*, equal in height to the

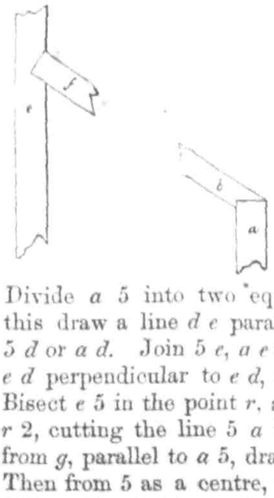
distance between upper and under floors, are secured to the floor; the post *c c* is provided with a mortise *f*, fig. 385, into which a timber 3 by 2 is secured; the other end is let into the wall at *e*, fig. 384, and forms the beam on which the tread of the step *e* rests: the tread of the step *d* is supported by post *c* and wall *a*. A mortise *g*, fig. 385, is made at the corner of the post *c c*, in which the beam *f* rests, the other end being let into the wall at *f*;—this supports the tread *f h*. Another mortise, *h*, is made on the post, fig. 385, into which the beam is tenoned, the other end resting in the wall-hole at *h*, fig. 384; the beam *e*, fig. 384, is tenoned into *c c*, and is let into the wall at the other end; a beam is similarly fixed at *m*, at the level of the tread *g*, fig. 384; and from *m* to *c* an inclined piece is fixed to form the string of the steps from *m* to *c*, or *i* to *g*, fig. 384.

Fig. 385.



In fig. 386 *e* represents the post *m*, fig. 384: *a* the post *c c*; *f* shows the mode of attaching the inclined beam *c m* at the upper end, *b* that at the lower. The return steps at the top of the stair are supported on timbers *n o p b*, fixed in the same, as already described at *f e*, &c.

Fig. 386.



In fig. 387 we give a method of drawing a scroll and curtail step. Let the line 1 9 be the breadth of the scroll. Divide it into eleven equal parts. From the point 5 draw a line perpendicular to 1 9, and make 5 *a* equal to one of the parts in 1 9. Divide *a* 5 into two equal parts in the point *d*, through this draw a line *d e* parallel to 1 9, and make *d e* equal to 5 *d* or *a d*. Join 5 *e*, *a e*; bisect *e d*, and from *e* lay off half *e d* perpendicular to *e d*, to *c*, and from *c* to *f* parallel to *e d*. Bisect *e* 5 in the point *r*, and from this, parallel to *e d*, draw *r* 2, cutting the line 5 *a* in 2. Make *a g* equal to *a* 2, and from *g*, parallel to *a* 5, draw a line and make *g h* equal to *a* 2. Then from 5 as a centre, with 5 9 as radius, describe an arc 9 3, cutting 5 3 in 3: from the point *a* as a centre, with *a* 3

as radius, describe a curve 3 *b*, cutting the line *a b* in *b*. Next from the point *g*, with radius *g b*, describe the curve *g b* 4, cutting *g* 4 in 4; then from *h* with *h* 4 cut the line 9 5 in *p*; then from *r*, with *r p*, cut the line *r* 6 in 6; next from *f* with *f* 6 describe the arc cutting *f* 7 in 7; next from *c*, with *c* 7, cut *c* 8 in 8. Set off next the breadth of rail as 9 12; then from 5, with 5 12 as radius, describe the arc 12 10; from *a*, with *a* 10, the arc 10 *m*; from *g*, with *g m*, the arc *m n*; from *h* the arc *h* 0, joining the circle described from *c* at the point 0. The curtail-step is shown by the dotted lines *a′ a′ a′ a′*. In the majority of hand-rails the scroll lies horizontally, as in fig. 387, where *a* is the scroll and 12 9 part of the rail. In

Fig. 387.

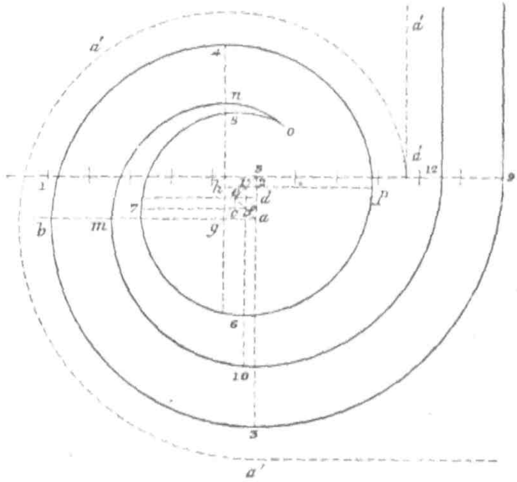
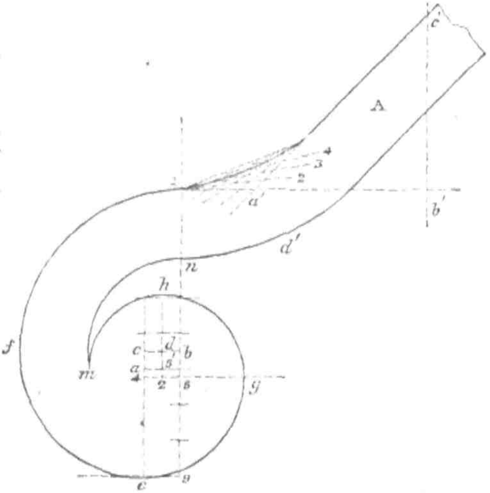


fig. 388 we give the method of describing a scroll which is placed vertically. Let 1 9 be the depth of scroll; divide it in eight equal parts; through the fifth of these, as 5, draw a line perpendicular to 1 9; lay half of one of the equal parts from 5 to *b*, and from *b* draw *b c*; make *b c* equal to one of the parts of 1 9; from *c* draw *c e*; divide *c b* in *d*, and draw *d* 2 parallel to *c e*. Divide *a* 5′, and set off the distance from 5′ to 2; through this draw 4 2 5; now from the point *b*, with *b* 1 as radius, describe the arc *b f*. From *c*, with *c f* the arc, *c e*; from 4 the arc 4 *g*; from 2 the arc 2 *h*; from

5′ the arc *h m*, and from *b* the arc *m n*. The baluster for supporting this scroll is placed at *e*. The "falling mould" A is joined to the scroll by an ease-off, or curve, which may be found as follows: From 1 set off to *a′* the distance of about a fourth of 1 9; take the pitch-board *a′ b′ c′*, and put the point *a′* at *a′*, and the side *a′ b′* to coincide with the line *a′ b′*, drawn from *f* the point perpendicular to 1 9; *a′ c′* is the "falling-mould" of the rail. Divide 1 *a′* into any number of equal parts, and set off on *a′ c′* the same number from *a′* to 4; number these points as shown, and from 1 draw lines to the points on *a′ c′*, and from 4 on *a′ c′* lines to the points on 1 *a′*; through the intersections of the corresponding lines draw a curve; and from *n* a parallel one joining *d′*.

Fig. 388.



In figs. 389 and 390 we give sections showing the form of

Fig. 389.

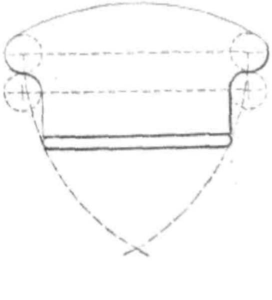
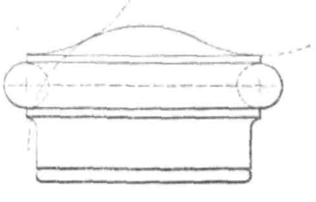


Fig. 390.



the rail, with the various lines and centres forming the curves; and in fig. 391 two varieties of balusters of an ornamental

Fig. 391.

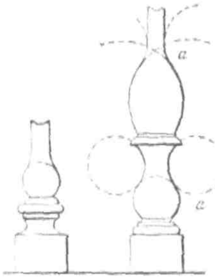
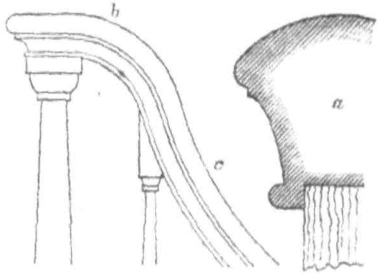
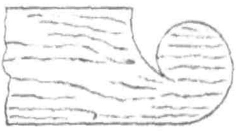


Fig. 392.



kind: *a a* is the form frequently adopted as the "newel" for supporting the centre of the scroll. Fig. 392 illustrates a portion of the hand-rail of a stair: *a* is a section of the rail *b*. The concavity *c*, necessitated by the sudden rise of the steps above, is termed the "ramp." The lowest step of a staircase is called the curtail step, fig. 393: it has its end turned in a spiral line towards the well-hole; the spiral being described in the same way as the "scroll," fig. 387.

Fig. 393.

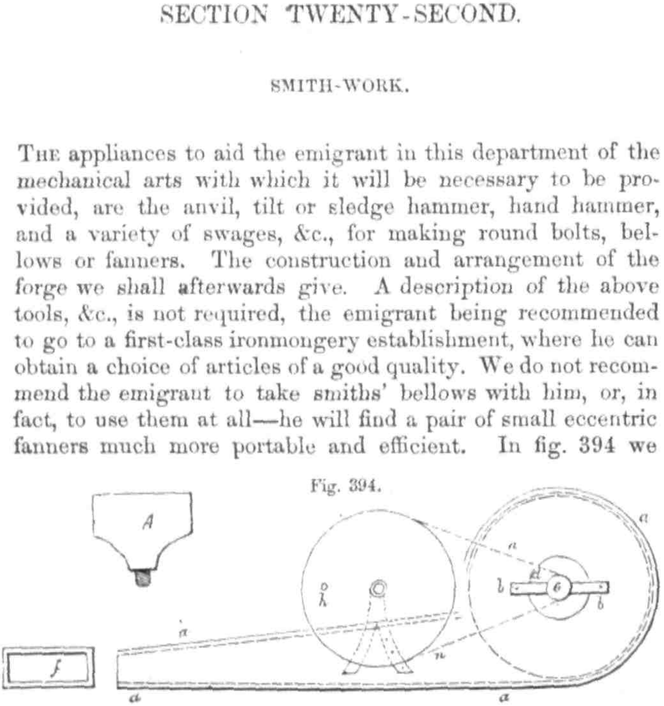


SECTION TWENTY-SECOND.

SMITH-WORK.

THE appliances to aid the emigrant in this department of the mechanical arts with which it will be necessary to be provided, are the anvil, tilt or sledge hammer, hand hammer, and a variety of swages, &c., for making round bolts, bellows or fanners. The construction and arrangement of the forge we shall afterwards give. A description of the above tools, &c., is not required, the emigrant being recommended to go to a first-class ironmongery establishment, where he can obtain a choice of articles of a good quality. We do not recommend the emigrant to take smiths' bellows with him, or, in fact, to use them at all—he will find a pair of small eccentric fanners much more portable and efficient. In fig. 394 we

Fig. 394.



give a side view of "concentric fan," drawn to a scale of 2 inches to the foot. Two sides, *a a*, *a à*, are constructed of ½-inch wood, or of sheet iron, with holes *d*, 2 or 3 inches diameter, to admit air to the interior: the extreme length of the sides is 18 inches, tapering to inch deep at *a à*; *f* shows the front of blowing aperture. The sides are kept apart a distance of 2½ inches, as at *f*, throughout their whole length; across each opening a piece of brass, ¾-inch wide, and ¼-inch

thick, is fixed, as *b b*. In the centre of this, corresponding with centre of circle *d*, a hole is bored to admit the spindle on which the arms of revolving fan are fixed. On one end of the spindle a small pulley *e*, $1\frac{1}{2}$ inch diameter, is fixed; this is turned by means of a band *n n* passing round the large pulley *h*. Fig. 395 is a view of the central spindle *a a*: a boss, or part larger in diameter, as *b b*, is forged upon the spindle; into this four holes are bored, as *c c*, *c c*, diagram to the right:—(three only are seen in the diagram to the left, fig. 395). These are screwed with a small tap (a set of which should be procured); and into these the arms or blades of the fan, as *A*, fig. 394, are screwed; the end of blades being made circular, and screwed with a die corresponding to the tap, which is used for the holes *c c*, in fig. 395. In place of having the fans revolving concentric to the case, as in fig. 394, the fanners will be more efficient, and a steadier blast kept up, if the blades revolve eccentric to the case, as in fig. 396. In fig. 397 an arrangement of a forge adapted for the use of the fanners is shown: the wheel for giving motion to the fan is fixed on a frame *f*, at the back of the forge, on the top of which the fan is placed. The large wheel is put in motion by a treddle and connecting-rod *g*, as in the knife-grinder's wheel, the upper end of the connecting-rod being connected with a pin inserted into the face of the wheel, at some distance from the centre of its revolution: *a a* is the body of the forge of brick-work; *b* the flat flagstone in

Fig. 395.

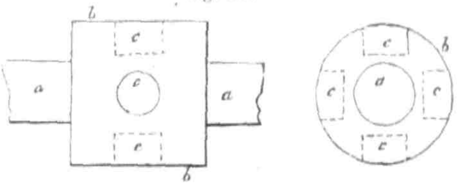
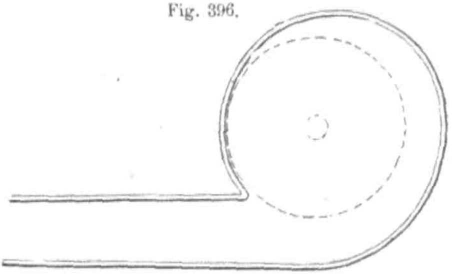


Fig. 396.



which the fire is made; *c* the fire: *d* the iron hood placed over the fire, conducting the smoke to the chimney.

Holes are bored in metal by a simple contrivance known as the "brace," delineated in fig. 398. It is formed of iron, about 1 inch in diameter—the upper part being formed into a point, which revolves in a small hole punched in the under side of a bar of iron of considerable length, one end of which, *m*, is inserted in a hole in the wall above the bench in which the operation is conducted, an assistant pressing on the other end. The drill *d* is inserted in the square hole made in the lower part of the drill at *c*; a piece of thin sheet-iron is passed round the brace at the bend,—this, being loose, allows the brace to revolve within it, thus saving the hand of the operator, and making the turning easier. A small indentation is made in the piece of metal in which the hole is to be bored. A few sizes of drills, as $\frac{1}{4}$-inch, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, should be taken by the emigrant; he can construct others from the patterns thus afforded, according as he may require them. In fig. 399 the method of riveting together plates of iron, or other metal, is illustrated. A hole is first bored through the two pieces to be joined, of diameter equal to that of rivet to be inserted. The upper end of this is to be enlarged for a small portion of its depth, by using a larger drill—this is called a "countersunk" hole, as *b*; a rivet *d* is made with one end, as at *e*; this is made hot,

Fig. 397.

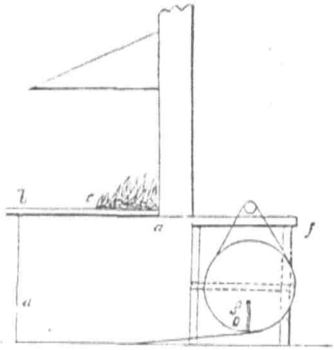
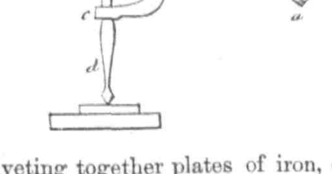


Fig. 398.



and passed through the hole, with the end *e* downwards; the part that projects through is to be then quickly hammered, and made to fill the countersunk portion *b*, and finished as in the sketch to the bottom, which represents two plates as riveted. Two portions of machinery, &c., are often held fast together by bolts and nuts, as in fig. 400. This method admits of the pieces being unfastened by merely loosening the nut with the key, as in fig. 401. In fig. 400, *a b* is the bolt, having the head *a*, which acts as a shoulder; the part *b* is screwed with the die for any desired length from the end. The nut is made square as at *d*, or eight-sided, by cutting off the corners, as shown by the dotted lines; a hole, a little less than diameter of bolt, is made in this, and screwed with a tap corresponding to the die used for the bolt. The sketch to the right shows the method of adjusting the bolt and nut in use; the upper piece is at *e*, the under one being at *f*; the bolt passes through a hole made in both pieces to be joined, and the nut *n* screwed at the upper end by means of the lever or key, *a b*, fig. 401. The key *c* is sometimes made bent, having holes *d e* of different sizes at the ends, so as to take in nuts of two sizes. A simple hinge may be easily made of thin sheet-iron, by bending it round a wire *d d*, fig. 402, which is fastened to the edge of one side, say of a box, the flat piece of iron *e* being nailed to the lid: *a c* is an end view, and *b* the thin sheet-iron, bent at the end, to pass over the wire *d d* and *a*. In fig. 403 another simple hinge, made of sheet-iron and small iron-wire, is delineated: the part *d e f f* is nailed to the lid of the box or door, the part *c b* to the edge or the side. The staple on which the hinges of large doors, as those of stables, are hung, is

Fig. 399.

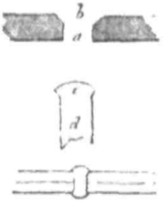


Fig. 400.

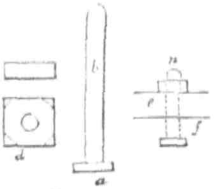


Fig. 401.

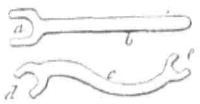
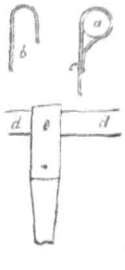


Fig. 402.



generally fastened in an aperture made in the wall, as at *c*, fig. 404: the staple *a* is inserted, and a mass of clay *e b d* is worked round it, and attached to the wall in such a way as to leave a sort of cup or cavity all round the staple; into this cavity melted lead is poured, which surrounds the staple, and, when cold, firmly holds it in the wall. Care must be taken not to admit water into the hole in the wall, as the lead will be forcibly driven out, to the danger of the operator, by the sudden formation of steam: *m f* shows an enlarged view of the hole, the dotted lines representing the mass of clay. The form of hinge used when this staple is adopted is shown in two views in fig. 405. The upper sketch is a side view, the lower an edge view. Holes are punched in the limb *b*, by which to fasten the hinge to the door; a hole is made in the eye *c*, into which staple *a* goes. A simple catch to be placed in the inside of a door to fasten it, so as to prevent any one from opening it from the outside, is delineated in fig. 406: *e* is the staple, formed by bending $\frac{1}{4}$-inch wire, and sharpening the ends; this is driven into the *door-post*: *a b* is the catch, a small hole in which is made at the eye *b*; a staple similar to *e*, but much smaller, fastens the catch *a b* to the *door*, one end of the staple passing through the eye of the catch *b*: the catch is thus hung loosely, and when not in use hangs downwards. When the door is to be fastened, the bent end of the catch *a b* is to be put into the hole of the staple *e*, fixed on the door-post *c c*. A simple catch for an outside or inside door may be easily made as delineated in fig. 407. The staple *e b* is driven into the door-post so far up as to leave a distance of some $\frac{1}{2}$ inch between the face of the post

Fig. 403.

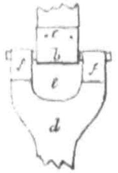


Fig. 404.

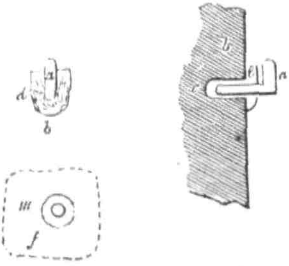


Fig. 405.

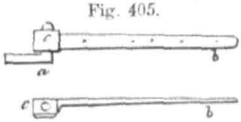
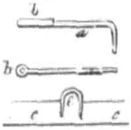


Fig. 406.



and the inner edge of the shoulder *e*; the bolt *d* is to be nailed to the door, by a nail passing through the eye *c*. The hole in the eye must be longer than the nail which fastens it to the door, so that the bolt can be moved up and down easily, as on a centre at *c*. The bolt is lifted up either from the inside or outside by a finger-piece *g f h*, which passes through a small hole made in the door, in such a position that its upper side or edge allows the under edge of the bolt *c d* to rest on it, when the bolt is lying on the head of the staple *e b*, as *a* in the sketch to the top. The finger-piece is fastened so as to vibrate on the centre *f*; by pressing in the part *h*, the end *g* is raised, which acts on the bolt *c d*, and raises it out of the catch at *a*; the door can then be pressed open. So long as the bolt is in the position *a*, the door remains shut. In soldering sheets of tin together, the edges should be bent in for a quarter of an inch in breadth, and the two sheets clasped together in the manner shown in fig. 408, at *b h*, and then closely laid, by placing the joint in a small anvil having a narrow undulation on its upper face, and hammering the upper face of the plates. A tool termed a "swage" is used by tinsmiths, but this simple operation will suffice, as above described. Bolts made of copper are used for soldering joints in tin ware, pointed as in the figure. The points should be cleaned just before being used, by being filed with a rough file. The solder used is made of lead and tin, in equal parts, fused together. Pounded rosin is used as a flux. In soldering, the two edges to be joined must be scraped very clean with a rough tool, and a little of the pounded rosin laid along the intended joint. The bolt, having been heated to redness in the fire, and the point properly cleaned, is rubbed up and down for a few seconds on a stone with some rosin, and then applied to the solder. A little portion of this is melted and taken up with the bolt, to which it adheres; it is laid on the joint as evenly as possible. When cool the two edges will be united, and will be water-proof.

Fig. 407.

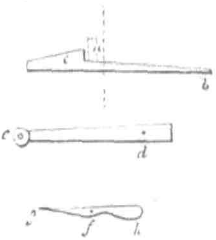


Fig. 408.

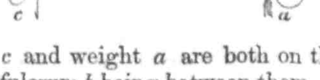
SECTION TWENTY-THIRD.

PRACTICAL MECHANISM, AND THE FITTING AND CONSTRUCTION OF MACHINES.

All mechanism, however complicated may be its construction, and numerous and diversified the movements it has to perform, is reducible to several simple elementary forms, these being known as the "mechanical powers," and termed the "lever," "pulley," "wheel and axle," "inclined plane," the "wedge," and the "screw." The term "mechanical *powers*" is rather apt to convey the notion that they create power; but they merely act as the agents by which we transmit a certain force or forces to certain desired points, or diffuse it over the various parts, or concentrate it on one part of a machine. The various forces thus put into action will be found to be just equal to the original force employed. It is not our intention here to go into the various points connected with the theory and practice of mechanics, our treatise being concerned particularly with *construction*. We only propose to describe the nature and form of the simple mechanical powers, as introductory to our illustration, referring the reader desirous to study the matter further to other works, such as "Mechanics and Practical Machinery," published in *Chambers's Educational Course.*

Taking the "powers" in their order as we have enumerated them, we first notice the lever. Of this there are three orders. In the "lever of the first order," fig. 409, the fulcrum *b* is between the power *c* and the weight or resistance *a*. In this the power *c* and weight *a* are both on the same side of the lever—the fulcrum *b* being between them. In the "second order of lever"

Fig. 409.



illustrated in fig. 410, the fulcrum *a* is at one end, the power *c* at the other, and the weight *b* between them. In this case the weight and fulcrum are both on the same side of the lever, the power being on the other. In the "third order of lever," illustrated in fig. 411, the fulcrum *d* is at one end, the weight *f* at the other, both being at the same side of the lever, and the power *e* between them on the other side.

Fig. 410.

The first order of lever is illustrated by the action of a pair of scissors—the pin being the fulcrum, the hand the power, and the cloth, or other material to be cut, the resistance. The second is illustrated by a wheelbarrow, where the axle of the wheel is the fulcrum, the man between the poles the power, and the load in the body of the barrow the resistance. A man in lifting a ladder perpendicularly, to place it against a wall, illustrates the third kind of lever: the ground on which the ladder rests is the fulcrum; the power of the man, exerted on a part of the ladder near the fulcrum, the power; and the weight of the ladder the resistance. The various rules for calculating the effects of levers will be found in the work referred to in page 238. Combinations of levers are used for various purposes, the most useful and ingenious of which is that displayed in the arrangement of the cart-weighing machine, illustrated in fig. 412: *a a a a* a square frame, at the corners of which are placed the fulcra *b b b b*, on which the ends of the curved levers *d d d d* rest. The extremities *e* of these are connected by means

Fig. 411.

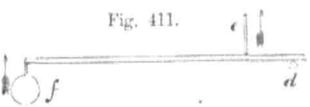
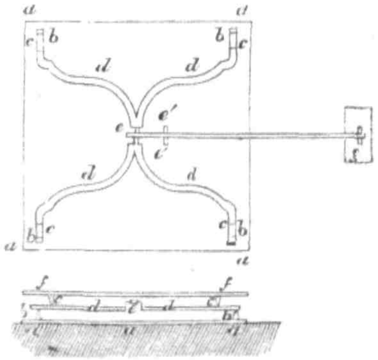


Fig. 412.



of a steel link to a centre, at the end of a lever *e g*, of which the fulcrum is at *e′ e′*, and the weight at *g*. The top plate *f f*, on which the load to be weighed rests, is supported by four points or supports, with knife edges, taking into slots made on the upper side of the levers *d d* at the points *a c c*, 5 inches from the fulcra *b b b b*. The distance from fulcra *c c c c* to centre of lever or link *e g* is 20 inches, that from *e* to *e′ e′* 6 inches, and from *e′ e′* to *g* 42. The arrangement is such that every cwt. on the table *f f* balances 4 lb. suspended from the end of the lever *g*.—The lower diagram is a section.

The second kind of mechanical power is the "pulley," illustrated in fig. 413. This, in fact, affords the advantage of a variety of levers acting on the same fulcrum, which is the axle of the pulley at *a*, the power being at *c*, and the weight at *b*. The lever in this instance is of the first order. The pulley, by another arrangement, can be made to act as a lever of the second order, as illustrated in fig. 414. Let the weight *e* be suspended from the axis of the pulley *c*; let a rope be passed over the pulley and fastened at one end, as at *d*, and the power applied by pulling upwards at the other. By this arrangement a power of 1 lb. at *a* will balance or suspend a weight of 2 lb. at *e*. The diagram illustrates also an arrangement of pulleys where the first and second levers are employed—the pulley *b* acting as a lever of the first order, and enabling the weight *a* to be applied in a more convenient form: in this there are two fixed points, one of which serves as the fulcrum of the pulley *b*, exemplifying a lever of the first, and the other *d* that of the pulley *c* of the third kind of lever. Fig. 415 illustrates another arrangement, with three movable pulleys, *e c g*, by which a power of 1 lb. at *a* will balance a weight of 8 at *m*.

Fig. 413.

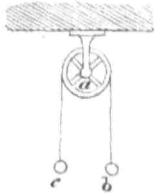
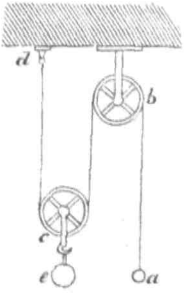


Fig. 414.



The third kind of mechanical power, the "wheel and axle," is a modification of the pulley, in which pulleys of two diameters are employed, both on the same axis: thus, in fig. 416,

the axis *b* is the fulcrum, *a b* the long end of the lever, *b c* the short end. By passing a rope over the circumference of the small pulley or axle *d c*, and suspending a weight *f* from it, and by similarly passing a rope over the circumference of the wheel *a*, and suspending a power *e* from it, a small power at *e* will balance a large weight at *f*. A familiar illustration of the "wheel and axle" is found in the plan used for raising buckets from wells, as also in the capstone, and the ordinary crab or winch, by which heavy weights are raised, and also in a train or combination of toothed wheels. A very slight examination of these three mechanical powers will suffice to show that they are reducible into one—namely, the *lever*. This, then, may be taken as representative of the first class of mechanical powers. Again, as the wedge and the screw are reducible into the inclined plane, so may we take this as the representative of the second class of mechanical powers. Of the inclined plane a very familiar illustration is met with in the method employed by draymen to move a heavy barrel into a cart, by rolling it up planks placed in an inclined position. The power of a small weight *f*, fig. 417, to balance or drag up a large one *g*, is most advantageously employed when it acts in a direction parallel to the face of the plane, as *d e*, parallel to *b a*. The line *g i* represents the direction and amount of the force of the weight *g* as acted upon by gravity; through *g*, parallel to the face of inclined plane, draw *g l*, and through *i*, parallel to this, *i h*; from *g* draw *g h*, perpendicular to *l g*, and from *i*, *i l*. Then the line *g h* represents the

Fig. 415.

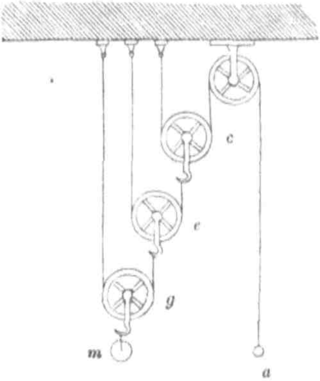
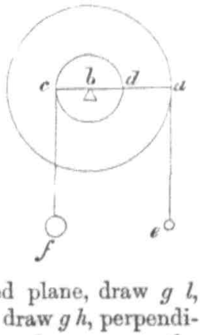
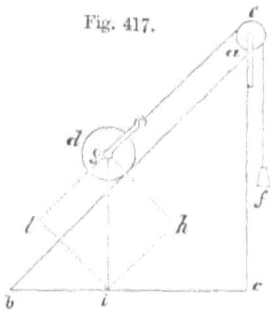


Fig. 416.



pressure of the weight *g* upon the plane, and *h i* the inclination to slide down it, and *g i* the weight of *g* acting by gravity: hence is deduced the rule by which the power *f* requisite to balance *g* is obtained. Multiply *g*, the weight, by *a c*, the height, and *a b* the length of the face of the plane, the product is the weight of *f*. By joining two inclined planes, as *c b d*, *b d a*, fig. 418, at their bases, a wedge *c d a* is obtained. If two bodies are pressed against the sides *c d*, *d a*, a power as a weight placed at *b*, or a succession of heavy strokes at the same point, will tend to separate them.

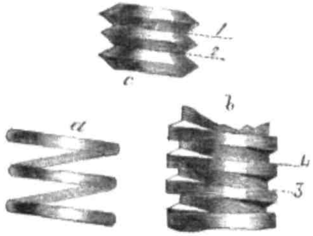
Fig. 417.



As the pulley multiplies the extent and mode of action of the lever, so the screw multiplies the extent and mode of action of the inclined plane. By winding a surface of paper cut into the form of an inclined plane upon a cylinder, the idea of the formation of a screw will be readily obtained. In fig. 419, *c* shows the form of screw usually adopted where the

Fig. 418.

Fig. 419.



incline is angular; *b* that where the thread is square: *a* shows a spiral or open screw. To make the power of the screw available, it must work within an internal screw *c c*, fig. 420, which is generally made of a short length, and is termed the nut, and is actuated by a lever *d d* passing through the head *a* of the screw *b*. In this arrange-

ment, which represents that of the "screw-press," the nut *c c* is fixed, and by turning the handle *d d*, the end of the screw presses on the material *e* resting on the base of the press *f*. The power of the screw is much increased by cut-

Fig. 420.

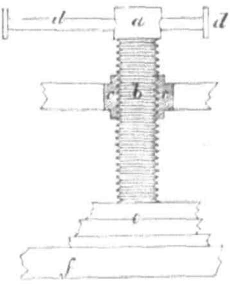
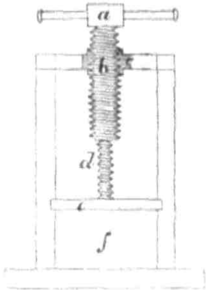
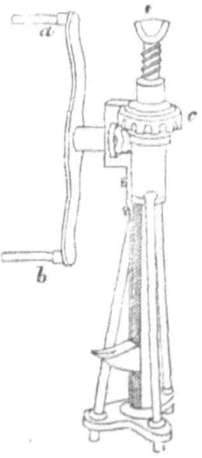


Fig. 421.



ting the threads fine and lengthening the lever. These two desiderata are not always easily obtained, and an arrangement has therefore been introduced, as illustrated in fig. 421. The screw *b* works in the nut *c*; the screw cylinder *b* is made hollow, and is provided with an internal screw, into which the screw *d* works; and this is attached to the table *e*, which presses in the material put into the space *f* by turning the lever *a*. The board *e* is depressed or raised for each revolution of the handle *a*, a distance equal to the difference between the pitch of the two screws *b* and *d*.

Fig. 422.



A useful application of the screw is exemplified in Thornton's Lifting-Jack, fig. 422. By turning the handle *a b*, a small pinion acts upon the mitre-wheel *c*, and raises the part *e* on which the weight to be moved rests.

Analysis of Machine Construction. — Parts of machinery are joined together, or kept in close contact, by means of bolts or nuts, and rivets: the former method is in use where the contact is arranged to be adjusted from time to time; the latter, where the junction is permanent.—(Illustrations of the two methods will be found in figs. 399, 400, Section Twenty-Second.)

In fig. 423, the stud *e* of the vertical shaft *a* is passed through the eye of the handle *c*, and fixed by the nut *b*, the upper part of *a* being turned down and screwed. The handle *c* may also be fixed to the stud *e*, or lowered as desired, by having a pinching-screw *d*, passing through a screwed aperture in the boss or projecting part *f f*. By turning the pinching-screw, the end presses against the surface of the stud *e*, and keeps the handle fixed in one position.

Fig. 423.

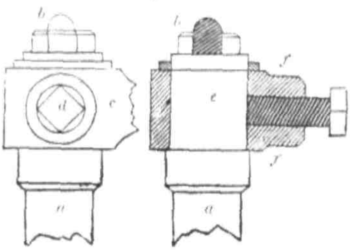
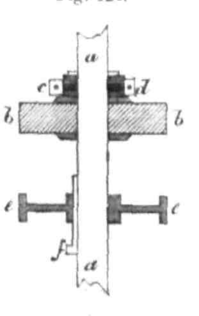


Fig. 424.

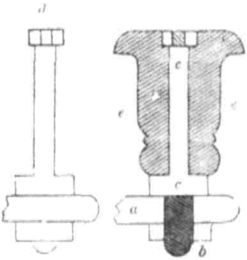


A similar arrangement of pinching-screw is illustrated in fig. 424, where the wheel or pulley *b b* is fixed to the shaft *a a* by the pinching-screws *c d*.

In fig. 425, which represents the other extremity of the handle, of which *c*, fig. 423, is part, the spindle *c c* is screwed to the handle *a a* by the bolt and nut *b*. To assist the operator, a wooden part *e e* is made to pass over the spindle, and revolve easily thereon. This is prevented from being passed upwards by the small nut *d*, which lies in a recess in the upper part of the wooden handle *e e*. In the arrangement shown in figs. 423, 425, the shaft *a*, fig. 423, is vertical, while the handle or lever *c*, fig. 423, and *a a*, fig. 425, is horizontal. The handle *e e*, fig. 425, allows the arm of the operator to turn the lever *a a*, without losing the hold or grasp

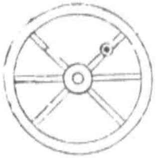
of the hand (see fig. 398). Two forms of keys are illustrated by fig. 401, in Section Twenty-Second. They are used for tightening and loosening nuts. Shifting-keys or spanners are also in frequent use. By turning the handle it acts upon a screw which moves one jaw or cheek of key, further from or nearer to the other and fixed jaw, according to the direction in which the handle is turned: the distance being thus adjustable, a large variety of sizes of nuts can be grasped.

Fig. 425.

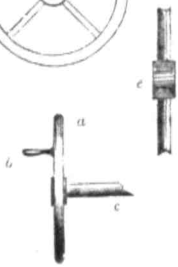


Where screw-bolts have to be moved frequently, as in adjusting stop-valves of steam-engines, or the screw of a turning-lathe, the lever used is not a key, but is in some instances in the form of a wheel: *a a*, fig. 426, fixed on the shaft of the screw *c*; by turning the wheel either by the arms or by the handle *b*, the shaft *c*, and consequently the screw, of which it forms a part, may be moved in either direction. The wheel may either revolve vertically, as in the diagram, or horizontally: in the former case the arrangement is adopted in the shifting head of a turning-lathe.

Fig. 426.



In fig. 427, the screw-bolt *a a* is turned in either direction by the lever *c c* passing through a hole in the bolt-head *b*. One end of the lever *c*, as *e*, is forged solid, the other is either screwed on or riveted, as at *g*.



In joining two pieces of metal, a hole is bored or punched through both at the same place, and a rivet with a head is passed through this, one end being hammered into a conical shape *d*, thus clinching the two firmly together (see fig. 399). Driving-belts or straps are joined together generally by small copper rivets and tin washers: *a b* are the ends to be joined (fig. 428), and *c* the rivets or washers: *h* shows a tin

washer. Sometimes belts are joined by leather thongs passed through both belts, somewhat as in the arrangement shown at *f*.

Lever handles are joined to their corresponding parts by means of a modification of riveting. Part of the lever handle is terminated with a collar, and a smaller part turned down. This passes through an aperture made in the part to which the handle is to be fixed. The hole is what is termed "countersunk" at one side—that is, made of larger dimensions, by partly boring with a drill of larger diameter. When the handle is placed in the hole, a space is left all round; the end is then hammered down so as to fill up the vacancy, and left either rounded, as shown, or filed down flat with the upper surface.

Fig. 427.

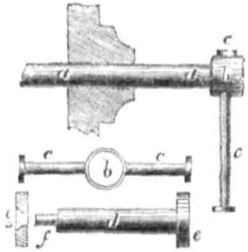
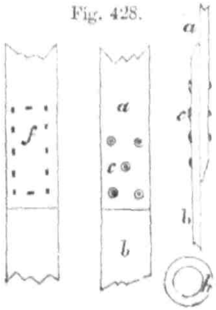
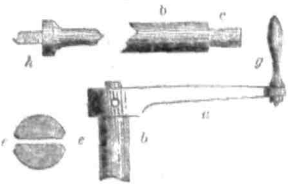


Fig. 428.



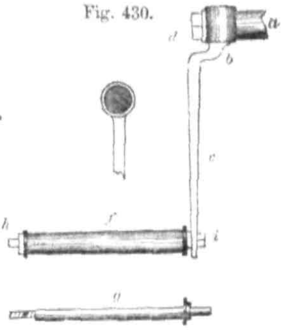
The end of the lever *f*, fig. 427, is riveted into *g* in this manner; as also the handle *b* of the wheel in fig. 426; *g*, fig. 427, *e*, 426, being the countersunk portion. The handle *g*, fig. 429, is fixed on the lever or shaft *b* by a pin passing through the eye of the lever *a* and the shaft *b*; the aperture through which this pin passes is countersunk at both ends, as *e e*. The handle *g* for moving *a* has its termination screwed, as at *h*, passes through an aperture at the termination of *a*, and is screwed tightly up by the nut, as shown; *c* shows the termination of the shaft *a*, with the aperture for the pin passing through. Fig. 425 shows another way of fitting this arrangement. The handle *c* is fixed to the shaft *a*, fig. 430, by the termination of this being passed through the eye *b* of

Fig. 429.



the handle *c*, and screwed tightly up by the nut *d*. To make the turning of the handle more easy to the hands of the workman, the part *f* is made of wood, and hollow, so that it turns round easily on the spindle *g*: by this arrangement the labourer can retain his grasp of *f* during the whole period of revolution of the handle *c*, instead of allowing the spindle *f* to turn round in his grasp as *c* revolved, as would necessarily be the case if the appliance *f* was not used. The spindle *g* is united to *c* by the nut *i*, *b* is then passed on, and retained in its place by the other nut, as shown in the diagram.

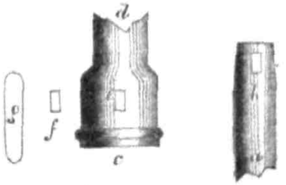
Fig. 430.



Wheels and pulleys are generally fixed on shafts by means of keys—not by the screw-bolt, as in fig. 424. Let *a a*, fig. 424, be the shaft in which the wheel *e e* is to be fixed. In the hollow centre or boss of the wheel a square groove or "slot," as it is termed, is cut; and at the part to which the wheel is fixed the shaft *a a* is slightly made flat. The wheel being placed in the proper position, the key or cutter *f*, fig. 424, is driven up the aperture, and pressing firmly both on the interior of the slot in the wheel and the periphery of the shaft, the two are firmly fixed together. In some cases two key-seats or slots are cut, and sometimes four, as in the case of fly-wheels and heavy gearing.

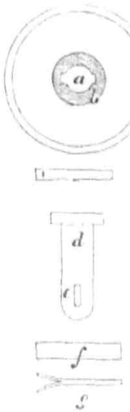
Cutters or keys are used for various purposes in machinery. Thus the pump-rod *a*, fig. 431, is firmly attached to the eccentric strap, which works it up and down, part of which is shown at *d e c*. By passing the tapered end *b* into the hollow *c*, and driving the cutter *g* (an end view of which is at *f*) through the apertures made in *a* and *c* at the points *b* and *e*, the rod *a* is fixed to *c*. Where two parts are joined with a movable joint, a pin *d e*, fig. 432,

Fig. 431.



is passed through the eye of the joints, and kept in its place by a cutter *f* drawn through the aperture *e*. A side view of the cutter is given at *g*. To prevent the cutter from working out of its place, the end is usually split up for a portion of its length in the direction of its thickness; and after it is passed through the aperture *e*, it is opened up, as *g*, fig. 432. By striking on the end *e*, when it is desired to remove the pin, the ends go together and allow of the cutter's removal; the pin is then taken out, and the two parts disconnected.

Fig. 432.



The parts of a shaft on which it revolves are termed "journals," as *a a*, fig. 433; *b d*, fig. 434. They are usually of smaller diameter than the other part of the shaft; the parts terminating them are known as "ruffs" or "collars," as *b b*, fig. 433; *c d* show the key-seats cut or filed on the shaft on which the wheels or pulleys are fixed (see fig. 424, and *a b*, fig. 432). Where shafts are of small dimensions they are termed "spindles," as fig. 435: *a a* are the journals;

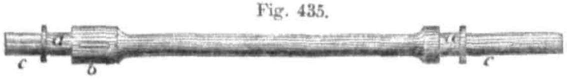
Fig. 433.

the part *b*, on which a wheel is fixed, is termed the "boss," *c c* are key-seats for fixing wheels, &c., *outside* the bearings.

Fig. 434.

When shafting is required of great length, the various portions are joined together by what are known as "coup-

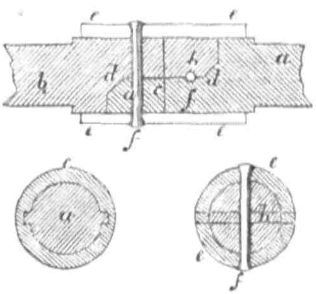
Fig. 435.



lings." A form very generally adopted is the "round coupling." The two shafts are squared up at the ends, as *c* of *a b*, fig. 436,

and a ring or round coupling-box *e e* passed over both, and the whole firmly secured together by two pins *b f*, placed at right angles to each other, and tightly riveted into countersunk holes made in the coupling-box *e e*. In place of putting the ends of the two shafts to be joined square up to each other, the half-lap joint is used, as in fig. 436, at *d d*; a coupling-box being used, as above stated, to keep them together. The coupling-boxes, in place of being pinned together, are keyed on exactly as the wheel *a* is keyed on the shaft *b b*, fig. 424.

Fig. 436.

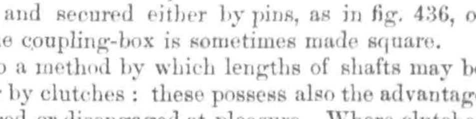


In place of the round, the square coupling is sometimes used: in this case the termination of the shafts is square; a round coupling-box, with an aperture of exact size as shaft, is passed over and secured either by pins, as in fig. 436, or keyed on. The coupling-box is sometimes made square.

There is also a method by which lengths of shafts may be joined together by clutches: these possess also the advantage of being engaged or disengaged at pleasure. Where clutches are used, two bearings are indispensable.

In fig. 437 the two shafts *a b*, *a b*, may have common motion, by sliding the clutch *d* into contact with the part *c*, provided with similar indentations and projections, fixed to the end of the shaft *b a*. The sliding-clutch *d* is made to revolve with the shaft *b*, by the intervention of the ribs *e e*, which project from *b*, and pass into slots or grooves cut in the interior of the sliding-clutch *d*. These, at the same time, allow it to slide along laterally: *b b* are the bearings of the two shafts. Another form of clutch is shown in fig. 438: *a* the bearing of a shaft, on the end of which a wheel or pulley *d d* is fixed; the boss of this is provided with projections *c c*, *f f*, similar to

Fig. 437.



those of the clutch *c d*, fig. 437, which is connected with the shaft *b*. When one shaft is at an angle to the other, the coupling of the two together is effected by the use of the "universal joint." This is illustrated in fig. 439. Let *a b* be a horizontal shaft to which the motion of the horizontal shaft *c d* is to be communicated; the intermediate shaft *c b*, placed at an angle according to the height which *a b* is above *c d* is employed—the universal joint being at the points *c* and *b*. A principal

Fig. 438.

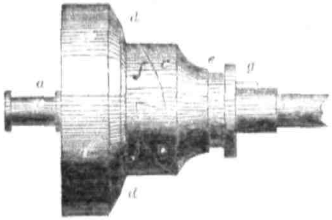
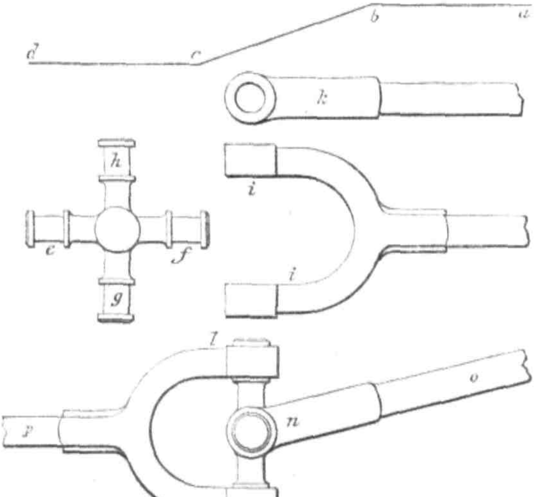


Fig. 439.



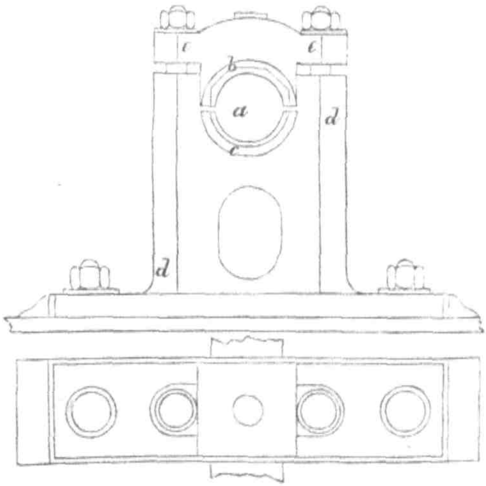
feature of the joint is the "cross;" this has four arms, with "collars" and "ruffs" at each arm, as at *e f g h*. The end of each shaft, as *c b*, *c d*, is finished with a bowed end with eyes: a front view is shown at *i i*, a side view at *k*. The

eyes of one of these bows embrace two of the collars of the cross, as *e f*, while the eyes of the bow of the other shaft embrace the other collars, as *g h*. Thus, while one of the bows is vertical, as at *l m*, the other, *n o*, is horizontal. The shaft *p* corresponds to *c d*, the shaft *o* to *c b*.

To reduce the friction evolved by the continual revolution of shafts, &c., the journals revolve in brass bushes or steps These are made in two parts, one of which is placed in the support in which it rests: the shaft is then placed in this; the other portion of the bush is next placed over the top portion of the journal, and the whole retained in position by appropriate means now to be described.

Horizontal shafts are supported by plummet blocks or pedestals. In fig. 440 we give an elevation and plan of one

Fig. 440.



of these. The cover *e e*, of which *e e*, fig. 441, is a section, is kept in its place by the projecting snugs, one of which is shown at *e*, and the bolts passing through the bolt-holes *b*, and screwing into the body of *d d*, fig. 440. Instead of these bolts screwing into *d d*, holes pass through it from top to bottom, as *d*, fig. 441; and through these, long bolts are

passed, the heads of which fit into recesses in the sole of the block. In fig. 440, *a* is the shaft, *c* the lower, and *b* the upper bush or step, *e e* the cover. As the brasses or bushes wear, they are brought in contact with the journal by screwing down the cover *e e* by the bolts; the cover presses on the bushes, or a pinching-screw is sometimes used, which passes through the cover, and presses on the upper brass *b*. In fig. 441 the recesses *a c* for the reception of the bushes are circular, the bushes being kept in their places by means of projections which pass into the slots *a c*. In fig. 442 the upper bush or brass is hexagonal, as *c*, fitting into the hexagonal recess *a* in the cover *a b* of the pedestal. In the hexagonal form of bush no rib or slot is required to keep the bush from turning round with the shaft as it revolves, as in fig. 441.

Fig. 441.

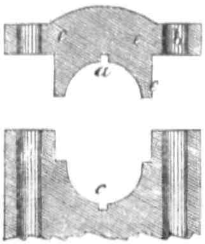
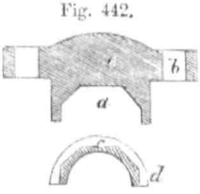
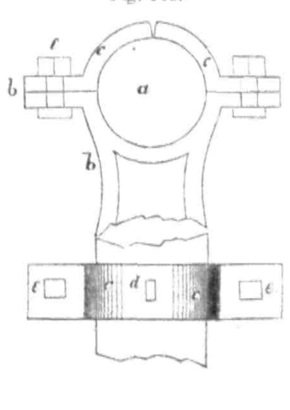


Fig. 442.



In fig. 443 a simpler form of pedestal or bearing for a horizontal shaft is illustrated; the shaft revolving in the lower part of *a*; the cover *c c c* is then passed over and joined to the lower part *b b* by means of two nuts, one of which is shown at *e*. A tapered hole *d* is made in the cover to admit oil to lubricate the shaft as it revolves.

Fig. 443.



When horizontal shafts revolve below a ceiling, &c., the bearings are supported by "hangers," as in fig. 444, where *a* is the hanger bolted to the ceiling, *b b* the horizontal shaft.

Where the shaft is carried along the face of a wall, the bearings are supported by "brackets," as in fig. 445, where *a a* is the bracket bolted to a plate in the wall *b b*. The pedestal is fixed in the upper side, as at *c*.

Vertical shafts, as *a a*, fig. 446, revolve in bearings similar to that shown in fig. 447, the end *c*, fig. 446, revolving in

Fig. 444.

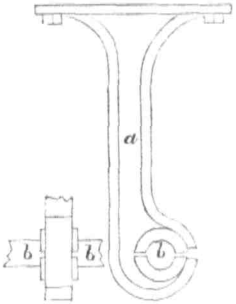
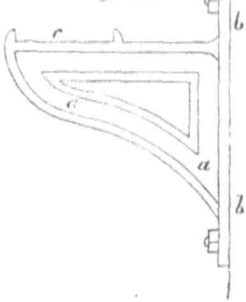


Fig. 445.



the hollow made in the brass block *b b*, fig. 447, which moves up and down in the case *a a*. The whole is contained within the covering, as shown in the upper drawing. This diagram illustrates the bearing for the vertical shaft of a millstone, in which it is necessary to provide for the raising and lowering of the millstone. For this purpose the block *b b*, in which the shaft revolves, is made to slide up and down in *a a* by the lever *g*, which is acted upon by appropriate mechanism. The block *b b* is adjusted in its position by means of the pinching-screws *d d* acting upon *a a*. In bearings for vertical shafts, in ordinary cases, the brass block in which the shaft revolves is stationary, and is only capable of adjustment laterally by means of pinching-screws, as *d d*, fig. 447.

Fig. 446.

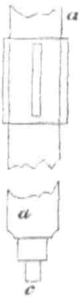
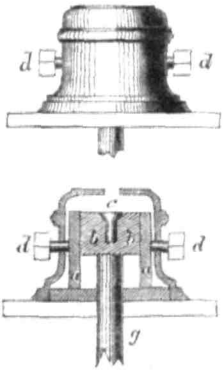


Fig. 447.



We now proceed to describe the construction of cranks and connecting-rods, and the manner of joining the various parts. In fig. 448 we give a view of a single crank used for turning-

lathes and small steam-engines: *a a* the journals on which the shaft revolves, *b* the journal embraced by the connecting-rod *c*.

In fig. 449 we give diagrams of a crank of the form usually adopted for steam-engines. The end of the crank-shaft is

Fig. 448.

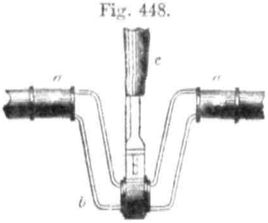
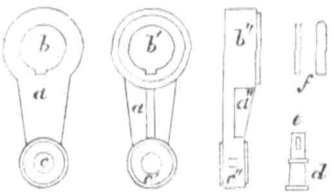
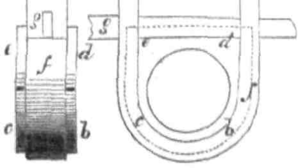


Fig. 449.



turned of the same diameter as the eye *b* of the crank; a key driven into the key-seat keeps the crank firmly fixed in the shaft; the eye in which the crank-pin is inserted is at *c*. In some forms the crank-pin is kept in its place by means of a screw and nut: generally, however, a slot is made in the pin and eye of the crank, and a key or cottar driven through both. The part *d* of the crank-pin is that which is embraced by the connecting-rod bushes or brasses: the part *e* is passed into *c′*, and a pin *f* driven through the slot made in the *d* and *c″*. How this is done we shall now proceed to show. Fig. 450 shows the end of the connecting-rod; the diagram to the left is a side view, that to the right a front view. The lower brass *c b*, and the upper brass *e d*, embrace the crank-pin exactly as the brasses *c b* embrace the shaft *a* in fig. 440. The lower brass *c b* is embraced by the strap *f f f*, and the butt *i* is passed between the sides of the strap, and the whole secured by keys or cottars *g h*, and "gib" *i*, passing through a slot made in the strap *f f f* and butt *i*. As the brasses wear, the journal of the crank-pin *d*, fig. 449, consequently revolves loosely with a rattling noise while working; the keys *g h* are then driven

Fig. 450.



up by striking on the wide end; this tightens the strap *f* round the lower bush *c b*, and brings the brasses nearer in contact with the journal of the crank-pin. The end of the butt *i* butts against the upper brass *e d*, passing between the flanges of the brass, the width of distance between which is equal to the thickness of butt. The width of strap is the same as the thickness of butt.

In fig. 451 we give views of the butt, that to the right being a side, and that to the left an edge view: *c b* are the key-slots. In fig. 452 we give views of the brasses or bushes: *a* is the space filled by the journal or crank-pin, *c b* the lower brass, *e d* the upper—the one half is shown in section, the other in elevation; *g* is a side view of the upper, and *h* of the lower brass; *h′* is a section of the lower brass *h*, *f* a top view of the upper brass *e d*; this being the part on which the end of the butt presses. In some instances both bushes are circular, the one being a counterpart of the other. They are provided with ribs or projecting parts, as shown in fig. 453: in this diagram *a a* shows a cross section of the bush, *b* a horizontal view or plan, and *c* an end view. The whole are put together in the following manner: The crank-pin *d*, fig. 449, is first embraced by the lower brass *c b*, fig. 452; the strap *f*, fig. 450, is then passed over, the circular end of which embraces the circular periphery of lower brass *c b*; the upper brass *e d* is then inserted between the sides of the strap, the distance between the flanges being such as to embrace closely, but easily, the sides of the strap. The butt *i*, fig. 450, is then passed between the sides of the strap, and rests against the upper brass *e d*; the gib *i* is then placed in the slot, and finally the keys or cottars *g h* driven home. The whole is thus fitted together,

Fig. 451.

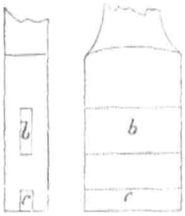


Fig. 452.

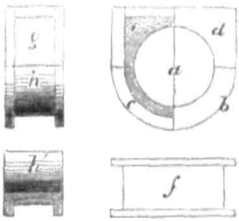
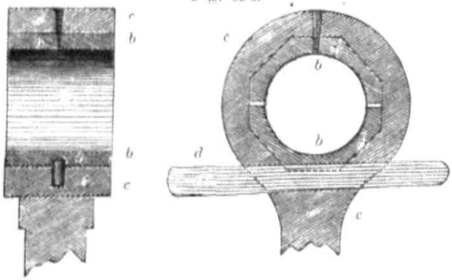


Fig. 453.

the brasses embracing tightly the crank-pin *e*, which is prevented from passing from between the bushes by the cottar, with which it is generally provided. To lubricate the journal, a hole is bored in a slanting direction in the side of the butt and through the upper brass.

In fig. 454 we illustrate another method of joining a connecting-rod with a crank-pin, or other journal: *c c* the head of the connecting-rod, in which an octagonal aperture is cut, into which two brasses *b b* are passed, which embrace the crank-pin; the key or cottar *d* keeps them in close contact, and is driven up as the brasses wear. An aperture is bored through the upper part of the head and the upper brass, through which oil is passed to lubricate the wearing parts.

Fig. 454.

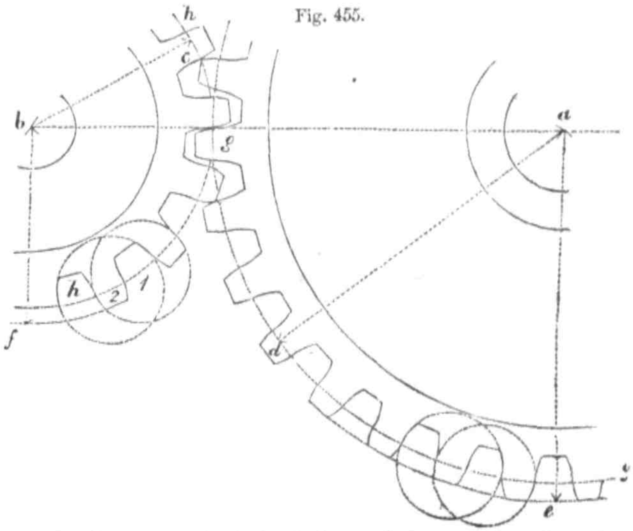


Teeth of Wheels.—The proper form to be given to the teeth of wheels is a matter of much importance, and has attracted the attention of able mathematicians and mechanics. The principle upon which the formation of the teeth of wheels depends is a development of the action of one roller revolving in contact with another, the irregularities of the surface producing motion. On the supposition that the power is equal and constant, the condition to be fulfilled in the working of teethed wheels is the uniform transmission of the power.

Fig. 455 represents part of a toothed wheel *a* and pinion *b*, *a* being the driving-wheel and *b* the driver. The line *a b* between the centres is called "the line of centres;" the interior dotted circle *g g* of the wheel *a*, and *h h* of the pinion *b*, are called the "pitch-lines" or "pitch-circles;" *a e*, *b c* are the pitch radii, and *a e*, *b f* the real radii of the wheels. The pitch line or circle is simply a circle, the diameter of which is equal to that of a cylinder which, in conjunction with another, would produce a rolling action. In bevil or mitre wheels, the pitch-circle is equivalent to the base of the

frustrum of the cone forming the outline of the wheel. By the pitch of the teeth of a wheel, is meant the distance between the centres of two contiguous teeth, or the space occupied by a full tooth and the space adjoining. Having determined

Fig. 455.

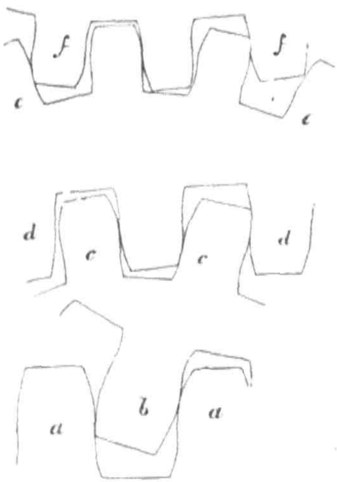


upon the diameter of pitch circle, and the number of teeth to be in the wheel, the pitch circle must be divided into as many equal parts as the number of teeth—the distance between each of these parts is termed the "pitch of the wheel." Radial lines, as *b c*, *b f*, *a d*, *a e*, fig. 455, are then drawn through these points from the centre of the circle, and the teeth described, as shown by the small dotted circles. For the purpose of reducing the number of patterns required for various sizes and pitches of wheels, a number of standard values have been adopted, in place of using indefinite numbers for the pitch of toothed wheels.

In fig. 456 we give diagrams illustrative of the shape of teethed wheels used for various purposes: *a a* are the teeth of a rack moved by a pinion, one of the teeth of which is at *b*; *d d* are the teeth of the "annular wheel," moved by an interior pinion, of which *c c* are the teeth; *f f*, *e e* are the teeth of two wheels revolving in contact. The best form of curve for

the teeth varies according to the peculiar circumstances under which they are employed. Thus, for the teeth of wheels and pinions acting in contact, the "epicycloid" is the best curve, this giving equal velocities to the pitch circles at every part of their revolution. For the teeth of a rack the "cycloid" is the form of curve found best. It being a matter of some difficulty to describe these curves correctly, it is the usual practice of mechanics to give the curves to the teeth by means of arcs of circles:—one method of doing this is shown in fig. 455.

Fig. 456.



In figs. 457 to 460 we give illustrations of the various modifications of toothed gearing in use, fig. 458 being the wheel-and-pinion movement, in which *b* is the pinion and *a* the wheel, the former being the "driver" or "leader," and the latter the "driven" or "follower." Fig. 457 is the internal wheel and pinion, where the motion of both is in the same direction, as shown by the arrow—not in opposite directions as in fig. 458. Fig. 457 represents the motion generally used in water-wheels, the internal wheel *b* being fixed to the inner periphery of the water-wheel, and the power taken off by the pinion *d*. In fig. 459 we illustrate the endless wheel and screw, by which the direction of motion of the shaft *b b* is changed to one at right angles, as the shaft of the pinion *a a*.

Fig. 457.

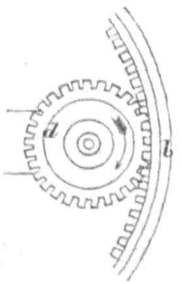
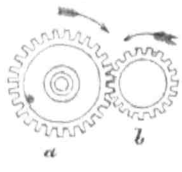
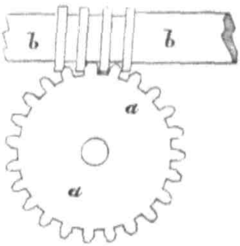


Fig. 458.



Another method of changing the direction of motion, and most generally adopted, is the employment of "bevel" or "mitre" wheels, as in fig 460; *a a* being the "driver," and *b b* the "driven."—(See *Illustrations of Machine and Mill Gearing*. W. and R. Chambers. 1*s.*)

Fig. 459.



Engagement and disengagement of machinery is most usually effected by what is known as the "fast-and-loose pulley," illustrated in fig. 461. Let *a a* be the shaft capable of being stopped or put in motion as required, without stopping the action of the prime mover, and *b b* the journals or bearings on which it revolves. Two pulleys are applied to the part *e e*, *c c* re-

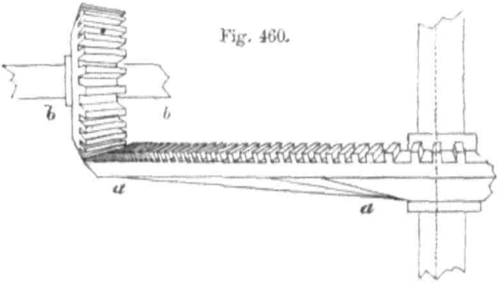
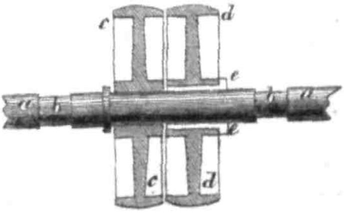


Fig. 460.

volving loosely on the shaft, *d d* being fixed by means of the two cottars *e e*. A belt is passed over one of these, and receives motion from the prime mover. So long as the belt is on the loose pulley, the shaft *a a* receives no motion, but on passing it from the loose c c to the fast *d d*, the shaft *a a* is put gradually into motion, the pulley *d d* being fixed thereto. The shock which is met with in changing the condition of rest of

Fig. 461.



a shaft, into that of motion by the "clutch" movement, is not much observable in using the "fast-and-loose pulley." In the latter, the belt moving gradually, from the extreme edge to the centre of the periphery of the fast pulley, the motion is gradually communicated to it.

The method of putting the "clutch" in and out of gear is illustrated in figs. 462, 463. The journal of the shaft *a*, fig. 463, is freely embraced by a fork *b* at the extremity of lever *b d*, vibrating on the centre at *c*, which centre or stud is supported on some fixed part of the machine. By moving the lever from side to side, the clutch partakes of the movement, and is disengaged accordingly: two studs *e e*, fig. 463, serve to keep the lever in any desired position. The same contrivance is applicable to shifting the belt from the fast to the loose pulley, fig. 461, or *vice versâ*, as shown in fig. 462. Supposing this figure to be in plan, *g* represents the position of the driving-belt, between the extremities of the fork *b*: this is capable of being moved from side to side, the end describing a curve, as shown by the dotted lines. As the lever is moved, the fork causes the belt *g* to take the direction required.

Fig. 462.

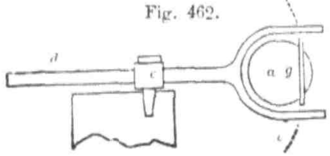
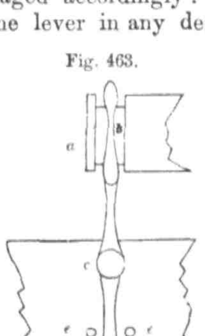


Fig. 463.



In a previous Section we have illustrated a simple piece of mechanism to aid the mechanic in drilling holes in metal, and performing many operations useful in repairing machinery. We here append an illustration of another arrangement which can be used by one operator alone, without the necessity of an attendant, as in the arrangement above alluded to. The part *c d*, fig. 464, of which *c′ d′* is a plan, slides up and down the part *a a*, which is fixed in a vice or other place. A pin passing through the end *c*, and one

of the numerous apertures in *a a*, keeps *c d* at any height required. The circular end *d* is screwed, and provided with a screw operated on by the handle *e*. The termination of the part *a* is circular, as shown at *b*, and at *b′* in the plan *c′ à b′*; *f* is the drill crank, *h* the drill, and *g* the piece of metal in which the aperture is being bored. The pressure on the drill is regulated by the screw *e*, which is depressed as the drill advances in the hole. The part *b* being circular, the drill is allowed to pass through the metal *g*, making a clean aperture. In fig. 465 we give various forms of drill: *a* is one very efficient in boring holes of large diameter; *b* and *c* smaller. The cutting-edges should not form too acute an angle as at *b*, as they are apt to snap off; *c* shows a safe and efficient degree of acuteness for the cutting-edges. As the illustrations show, the cutting-edges are ground so as to give the rope or bevel in opposite directions.

Fig. 464.

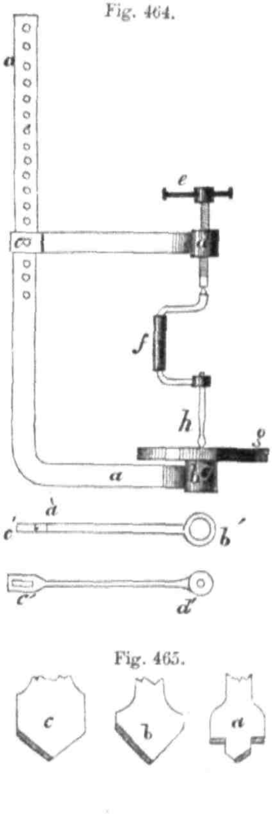


Fig. 465.

SECTION TWENTY-FOURTH.

BRICKMAKING.

The earth best adapted for bricks is that composed of a mixture of pure clay and sand: loam is also useful. In many situations, earth, properly constituted for brickmaking, is obtained in large quantities; where pure clay is only obtainable, it will be rendered less liable to cracking in burning by the addition of a little sand.

In commencing the operation of brickmaking, the ground is prepared by removing the turf and as much of the topsoil as is unfit for the purpose. These may be put aside in some convenient spot, to be used for refilling the space made by the removal of the clay. A level space should also be cleared, on which to prepare the brick earth. The earth is then dug out, and laid in heaps of several feet in depth. All pebbles and stones must be carefully removed as far as possible. The heaps being exposed to the frosts of winter, the earth is mellowed. In spring, after the mild weather has set in, the operations of brickmaking are to be entered upon with vigour. The first thing to be attended to is the "tempering" of the clay: this is effected by turning it over and over with spades, mixing a quantity of water with it, sufficient to render it plastic, and of a consistency to render it easily moulded. A hoe, or bent-pronged fork, is used for pulling the clay down from the heap; the water is then thrown over the portion pulled down, by means of a scoop, and the clay is turned over and over with the hoe or spade, and kneaded from time to time with a board, or treaded on by the feet of the workman. Too much attention cannot be given to the freeing of the clay from all pebbles, stones, &c. The presence of a pebble in a brick will very likely cause it to crack and break in pieces during the operation—this being more probable if the substance is of the nature of limestone.

The moulding-table is formed of rough boarding, placed on legs some 2 feet 8 inches, or 3 feet high, as convenience may dictate. A small wooden trough to contain water may be made at one end, the length equal to breadth of table —12 or 14 inches broad, and same deep; or the table may be made of greater length, in order to accommodate an independent water-box. The brick mould may be easiest made of wood, about an inch thick—its dimensions being ordinarily 10 inches long, 5 broad, and 3½ deep—the clay shrinking in firing, which reduces the dimensions of the finished brick. The mould should be made of sufficient strength, so as not to give, from the pressure of the clay in forming the brick. An instrument called a "strike" is used for levelling the top of the moulded brick; it may be made of wood, some 9 or 10 inches long, 1½ or 2 inches wide, and ¾-inch thick. The moulder, in forming the bricks, stands before the moulding-table, and is supplied, by a boy or attendant, with a lump or piece of tempered clay, calculated as nearly as possible to be of quantity sufficient to fill the mould, leaving a little over: the mould being previously dipped in the trough, so as to be thoroughly wetted in the inside, he dashes the clay into it, taking the "strike" and levelling the upper surface. The mould thus filled, the boy takes it away to the drying-ground; and the moulder, taking a *second* mould, fills it with the clay as before. The upper edge of the mould should, if possible, be covered with thin sheet-iron, brass, or tin; this will make the mould last much longer. By the time the boy has returned with the empty mould from the drying-ground, the moulder has filled the second mould, and which in its turn is taken to the drying ground, and the brick deposited. On the drying-ground being filled up with bricks to a sufficient distance from the moulding-table, the latter should be removed to a situation near the vacant space of the drying-ground.

Where wood is plentiful, and the quantity of bricks to be made not great, drying-sheds should be built of considerable dimensions, in which to dry the bricks. The sides of those sheds are formed of boards set edgewise: these break the currents of air passing through the sheds, and in some measure prevent drafts, which have a tendency to dry the bricks unequally. The great point to be attended to in the

drying of bricks is, getting the moisture to evaporate slowly and uniformly—sheltering them as much as possible from the direct action of the sun, wind, and rain. In laying the bricks on the drying-floor, they may be sprinkled with sand, which will relieve them of the superabundant surface-moisture derived from the wet sides of the mould, &c. The drying on the ground may take from one day to a week, according to circumstances. After being dried sufficiently to allow of their being handled, they are built up into hacks under cover, where they are allowed to remain until the operation of burning is ready to be gone through.

The *burning* of the bricks is the next important operation to be attended to. This is effected by placing them in a kiln, and subjecting them to heat. The simplest form of kiln is that known as the "rectangular." The walls are made of brick, not less than 3 bricks in thickness; or stone, if bricks cannot in the first instance be procured. A size sufficient to burn 20,000 bricks will be somewhere as follows: 14 feet long, 10 wide, and 9 high. At each end of the rectangular kiln, a door at one end (a door is sometimes placed at each end), and openings some 6 or 8 in number, are made in each side, exactly opposite each other—the dimensions of these apertures being 8 or 9 inches wide, and 24 or 36 inches high. The floor of the kiln should be made level. The bricks to be burned are to be introduced to the interior of the kiln by the door or doors, and built up in courses in a manner which can scarcely be described, but so as to form spaces or openings between the bricks—these being from top to bottom, so as to admit of the passage of the heat throughout the whole mass of bricks. In building up the bricks, flues or passages are to be made, connecting the holes made in the sides of the kiln, and of the same dimensions. The kiln being filled, the roof is formed by covering the last course with old burnt bricks, rubbish, turf, &c. The doorways are then built up, and the openings on one side of the kiln stopped up with burnt bricks. The fuel is then to be introduced through all the openings on the other side, and set fire to—the heat being kept up very moderately for twenty-four hours, in order gently to expel the moisture. This is known to be effected when the steam ceases to rise. The roof should not be completely made up until this is effected.

When heat has been applied for twenty-four hours, the holes on the side first used should be closed, and the other opened, the fuel being supplied through these ; thus both sides of the mass of bricks are subjected to the action of the heat. The fuel is supplied through these holes for twenty-four hours, when they are again closed. This process is alternately gone through until the burning is completed, which will be known by examining the upper course. Two or three weeks burning may sometimes suffice. On the burning being completed, the mouths of the flue-openings must be built up, and closing the roof in a most effectual manner: the bricks should then be allowed to remain in the kiln until they are cooled. The kiln should be protected on all sides by a low rough shed, to afford shelter to the workman while firing, and to prevent the wind blowing too strongly on the flue mouths.

We have here given a brief outline of one of the methods of brickmaking—full enough, however, to enable the settler to make bricks of sufficiently good quality for his varied purposes, and this by processes not at all difficult in their nature ; although in this, as in other branches, experience will be best derived from practice. The methods of making bricks are very numerous, and to give even a cursory detail of them would far exceed our limits. We have, therefore, contented ourselves with explaining one method by which they may be easily manufactured.

SECTION TWENTY-FIFTH.

ROOF-COVERING.—EXTERIOR AND INTERIOR FINISHINGS. PLASTERING.—PAINTING.

ROOF-COVERINGS, where wood is plentiful, can be most cheaply and readily made of what are termed shingles—these being thin pieces of wood sawn out to any convenient dimensions. In fig. 466 we give an illustration of the method of fitting up a roof with rectangular shingles. Those nearest the eaves are put on as *a b c d e*, and nailed securely to the narrow battens which are placed from rafter to rafter, the distance between these battens being regulated according to the length of the shingles. Each succeeding row of shingles overlaps the preceding one, as *f g h* overlap *a b c d e*: this prevents the rain from gaining access below the roof. The shingles may be made ornamental by cutting the ends in a circular form, as in fig. 467, or with angular points, as in fig. 468. In place of covering the

Fig. 466.

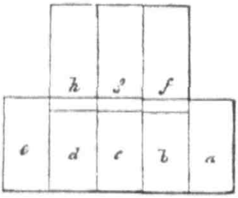


Fig. 467.

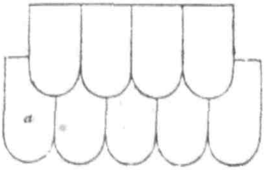
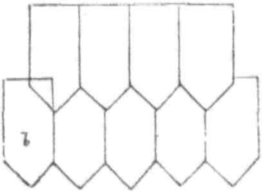


Fig. 468.



roof with shingles, boards of the length of slope of roof may be nailed on the rafters in the direction of the slope; the divisions between them covered with strips or narrow battens,

as in fig. 142; the whole being painted two coats after finishing. Where elm-trees are plentiful, the bark may be used for a roof-covering, for which purpose it is well adapted. In spring, when the leaves are just coming out, the bark will peel off easily; the pieces should be laid out to dry and flatten, the curved part being placed uppermost. On being flattened, they should be fastened on to the roof-battens with trenails, the holes being made true with an auger: each succeeding piece of bark must overlap the preceding one by at least 4 inches. Roofs may be thatched with straw, reeds, &c.; but where shingles or wood can be had, they should be used in preference. If slate can be had, it should in all cases be used, cut into rectangles of any required dimensions (20 inches by 10 will be found convenient), and nailed to the battens or boards placed across the rafters: they will form the most desirable and safest roof-covering that can be adopted. To keep the temperature below the roof as equable as possible, it would be advisable to have boarding over the rafters (instead of battens), on which to place the roof-covering, of whatever material; and if made double by a ceiling within a short distance below it, this desideratum would be more certainly obtained.

Under the present heading we purpose giving a few hints on the finishing of external and internal walls, comprising rough-casting, stuccoing, plastering, whitewashing, and painting. The outside walls of pisé houses are finished in two ways—these are, rough-cast and stucco. The former consists of a small quantity of mortar diluted with water in a tub; to this a trowelful of pure lime is added, so as to make the whole of the thickness of cream. Stucco is made with one bushel of unslacked lime to six bushels of clean sharp sand. To finish the walls with greater expedition, the joist-holes may be left not filled up; into these, joists may be inserted, on which to place scaffolding to bear the operatives. The walls are prepared for plastering by indenting them all over from top to bottom with numerous hammer or pick marks: the closer these are to each other the better.

The rough-cast is laid on as follows:—The indentations in the wall being first carefully swept, the wall being sprinkled with water, the workman takes his brush filled with rough-cast mortar and dashes it against the wall. The indentations in

the wall give the appearance of the ordinary rough-cast with pebbles in it. The scaffolding being placed at the top of the wall, the workman lowers his scaffold, takes out the joists, fills up the holes with bricks, mortar, &c., and, fastening his scaffold lower down, proceeds as before.

Stucco-finishing is laid on as follows:—The walls being previously indented, swept, and sprinkled with water, the workman places some mortar on a flat piece of board 12 inches square, provided with a handle, and with a plastering-trowel lays this on the wall, pressing it closely between the indentations, and working the surface, finally, fair and level, it being sprinkled at the same time by means of a brush with some of the thin mortar,—the poorer the mortar the better the stucco. Lime-wash is used as a final covering to the stuccoed wall. This is made by dissolving some unslacked lime in clear water, and sprinkling it on the wall before the stucco is dry. When applied in this manner the stucco sets very hard, and the white colour of the wash is so incorporated with it that it will never wash off, although no size or oil is used—indeed, the using of these renders the white dead and less brilliant; whereas, if the lime-wash is alone used, the colour will remain *naturally* white as long as the plaster lasts. All the plastering should be done at one time: new plastering never sets well with old. It is absolutely essential that the walls should be thoroughly dry before the plaster is laid on. If this is not attended to, the plaster will inevitably scale and blister off, leaving unseemly spots.

The method of rough-casting rubble stone or brick walls is as follows: — First wash the earth from the gravel or coarse sand, and bring to a uniform size by sifting it, or passing it through a screen; mix the gravel with newly-slacked lime-and-water, to the consistence of thick cream. Having cleaned the part of the wall to be operated on with a rough brush, a coat of lime-and-hair is laid on smooth, and, as fast as some two or three square yards are finished, the rough-cast is thrown upon it. Some recommend the first coat of lime-and-hair to be allowed to dry, and a second coat put on, on which the rough-cast is finally thrown. Instead of throwing the rough-cast on, small pebbles may be stuck in the mortar while yet in a soft state. This, however, is a tedious process.

Mr Downing recommends a strong and durable stucco for

the finishing of the outside of rough brick-and-stone walls as follows:—"Take stone lime fresh from the kiln, and of the best quality, such as to make a strong and durable mortar. Slake it by sprinkling or pouring over it just water enough to leave it, when slaked, in the condition of a fine dry powder, and not a paste. Set up a ¼-inch wire-screen at an inclined plane, and throw this powder against it. What passes through is fit for use; that which remains behind contains the core, which would spoil the stucco, and must be rejected. Having obtained the sharpest sand to be had, and having washed it so that not a particle of the mud and dirt (which destroy the tenacity of most stuccoes) remains, and screened it, to give some uniformity to the size, mix it with the lime in powder, in the proportion of *two parts* sand to *one part* lime. This is the best proportion of lime stucco. More lime would make a stronger stucco, but one by no means so hard—and hardness and tenacity are both needed. The mortar must now be made by adding water, and working it thoroughly. On the tempering of the mortar greatly depends its tenacity. The wall to be stuccoed should be first prepared by clearing off all loose dirt, mortar, &c., with a stiff broom. Then apply the mortar, in two coats: the first a rough coat, to cover the inequalities of the wall, the second as a finishing coat. The latter, however, should be put on before the former is dry, and as soon, indeed, as the first coat is sufficiently firm to receive it. The whole should then be well floated, trowelled, and marked off; and if it is to be coloured in water colour, the wash should be applied so as to set with the stucco. A cheap wash for the outside of wood cottages, outbuildings, &c., is made by slaking fresh quicklime with boiling water, and adding some sulphate of zinc—sufficient water being put in to bring the whole to the consistence of cream. The addition of the sulphate of zinc tends to harden the wash, and make it more durable. The addition of a little sulphate of iron will give the wash a warm tint, which will be much more agreeable to the eye than the pure white resulting from the above. A wash useful for brick-and-stone walls, rough-cast or stuccoed, is made by mixing equal quantities of clean, sharp, and rather coarse sand, and of fresh-burnt lime, in 6 or 8 gallons of water. This is to be laid on the walls with a brush, care being taken to stir the mixture up each time the brush is dipt into it, so as to mix the sand well up

The following is the recipe for making the celebrated stucco whitewash used in the President's House at Washington, United States :—"Take half a bushel of good unslacked lime, slake it with boiling water, covering it during the process to keep in the steam. Strain the liquor through a fine sieve or strainer, and add it to a peck of clean salt previously dissolved in warm water; three pounds of good rice, ground to a thin paste, and stirred in while boiling hot; half a pound of powdered Spanish whiting, and a pound of clean glue, which has been previously dissolved by first soaking it well, and then hanging it over a slow fire in a small kettle, within a large one filled with water. Add five gallons of hot water to the mixture, stir it well, and let it stand a few days covered from dirt. It should be put on quite hot: for this purpose it can be kept in a kettle on a portable furnace. It is said that one pint of this mixture will cover a square yard upon the outside of a house, if properly applied. . . . . It retains its brilliancy for years. Any required tinge can be given to the preparation by the addition of colouring matter." A fawn colour may be made by mixing four parts of amber, one of Indian red, and half a part of lamp-black previously dissolved in alcohol.

In many cottages, &c., the stucco already described as useful for outside may be adopted for inside walls, partitions, &c. Plaster proper is made of gypsum or sulphate of lime; this is burned or calcined in a simple rectangular kiln or enclosure, formed of brick walls. The largest lumps or stones of lime are placed on the floor of the kiln, in such a way as to form, as it were, a series of arches, into the space of which the firewood or fuel used in calcining is put, the smaller stones being placed above. After being calcined, the time for which operation varies according to the quantity of lime to be burnt, the lime is powdered either by hand or a mill, after which it is protected from the atmosphere until ready to be prepared for plaster. This is done by slaking the powder with water, the quantity of water depending on the degree of stiffness required in the plaster. The first coat is laid on the walls in a thinnish state, and left rough to take on the next coat, which must be laid on stiff, and smoothed up with a hand-trowel, the surface being levelled with a flat rule. For ordinary work, a plaster termed "coarse stuff" may be

made of common mortar mixed with coarse hair—cattle or horse, from the tanyard—and thoroughly incorporated. In laying this on brick or stone walls, the first coat, which is termed "rendering," is to be crossed or made rough with the trowel, in order to form a key to the next coat. This is not done where the work is "two coats" only. In this case the first coat or "rendering" is left smooth; the second coat is then put above this—the material for the second coat being of pure lime slacked with a small quantity of water, more being finally added to bring it to the thickness of cream. After being allowed to settle, the water is poured off, and the lime allowed to remain till, by the evaporation, it is brought to a proper thickness for working. Where fine stuff is used for ceilings, a little hair is mixed with it, the colour of this being white. Three-coat work is executed by first laying on a coat of coarse stuff, crossing it with the trowel; then above this another coat, smoothed and floated with a rule, and finally finished with a "set," or smooth coat of fine stuff. In partitions where laths are placed across the timbers, and in ceilings where only one coat of coarse stuff is laid on between the laths, the operation is termed "lath and plaster." A more finished method, where laths are used, is by first laying on a coat (leaving it crossed) of coarse stuff, thereafter a coat of fine stuff; a still higher kind of finish being—first, a coat of rough stuff, crossed; next, a second coat, smoothed; lastly, a coat of fine stuff. The tools used in plastering are simple —a variety of trowels, a small square board on which to placed a quantity of plaster while working, a handle being placed on its lower side by which it is held. The float is a rule which may be long enough to be worked by two men—it is used for levelling the surface.

Plastered walls may be *painted* in distemper—that is, by colours worked up with size instead of oil. The size is formed of a solution of glue. A good substitute for this size can be made by preparing potato-starch, adding some of it to a mixture of whiting and water. This colour has no smell, and makes a beautiful white colouring-wash for ceilings. Where whiting cannot be procured, chalk may be pounded very fine, and washed with pure water. In mixing up whiting and size for this kind of painting, any desired tint may be given by adding the colour finely ground. It must be borne

cold weather it must be mixed warm to facilitate its co-operation with the milk."—(SMITH's *Art of House Painting*). The following is a very durable paint—more so than the ordinary oil—recommended by Mr Downing for cottage-work—its hardness increasing by time: "Take freshly-burned unslacked lime, and reduce it to powder. To one peck or bushel of this add the same quantity of fine white sand, or fine coal-ashes, and twice as much fresh wood-ashes, all these being sifted through a fine sieve. They should then be thoroughly mixed, when dry. Afterwards mix them with as much common linseed oil as will make the whole thin enough to work freely with a painter's brush. This will make a paint of a light-grey stone-colour, nearly white. To make it fawn or drab, add yellow-ochre and Indian red; if drab is desired, add burnt umber, Indian red, and a little black; if dark stone-colour, add lamp-black, or if brown stone, then add Spanish brown. All these colours should of course be mixed in oil, and then added. This paint is much cheaper than common oil-paint. It is equally well suited to wood, brick, or stone. It is better to apply it in two coats—the first thin, the second thick."

The interior wood-work of cottages may be beautifully stained to resemble oak and walnut, by washing the cleaned surface with diluted sulphuric acid (1 ounce of sulphuric acid to a pint of warm water); this to be washed, when warm, evenly on the surface of the wood to be stained. The next operation is washing over the surface so prepared with a tobacco stain, made by boiling a quantity of tobacco with as much water as will cover it, allowing this to get dissolved to the consistency of a syrup by gentle boiling—this being strained before using. The stain is laid on with a sponge. When the wood is thoroughly dry, it is to be brushed over with 8 ounces of beeswax, ½ pint of linseed-oil, and double the quantity of boiled linseed-oil. A varnish for finally covering the surface of the wood thus stained is prepared by dissolving in a pint of spirits-of-wine a ½ lb. of seed-lac. Outside work may be stained by adopting Mr Wheeler's mode. "Take best rosin tar, or pitch—in the proportion of 1 gallon to every 4 gallons of the following—turpentine 1½ gallon, seed-lac dissolved in alcohol (in the proportion of 1 lb. to 1 quart) 2 quarts, cold linseed-oil ½ gallon, boiled oil ½ gallon,

beeswax 6 lb., ox-gall 1 lb.: mix all these together, and add the rosin tar first named. Lay it on with a large flat brush." We would recommend the emigrant to provide himself with a quantity of Stephens' dyes for staining wood: they stain the wood beautifully. The oak, mahogany, and satin-wood colours are 8s. per lb., and are simply dissolved in water: this quantity will make a gallon of stain. Being in powder, they are easily carried. Address—Mr Stephens, 54 Stamford Street, Blackfriars, London. Varnishes had better be procured ready-made. We have already given a recipe which will be generally useful.

SECTION TWENTY-SIXTH.

MORTARS. — CONCRETE. — CEMENTS.

Lime, as used for building purposes, is obtained from several of the varieties of stone, marble, and chalk, termed limestones. It is prepared by burning or calcining the stone, thus driving off the carbonic acid in which it abounds. After calcination it is reduced to a white powdery material, which greedily takes up water; it is then known as *quicklime*. In making mortar, fresh-burned lime is to be taken from the kiln, and laid in a heap in a convenient space, and, sprinkling a quantity of water on it, the lime begins immediately to crack and fall down, steam issuing from the heap in considerable quantities—a high degree of heat being at the same time induced. On the completion of the process of decomposition, the lime is reduced to an impalpable powder, which goes by the name of "slacked or slaked lime." The slacked lime thus obtained is next to be well mixed with water, forming a paste, and afterwards have the proper proportion of sand added—two-thirds sand to one-third of lime. The sand used in mortar-making is of three kinds—pit sand, river, and sea. The first is obtained in pits; the latter from rivers and the sea-shore. River water is the best to use for mortar; but all waters known as mineral are to be avoided. The sea-sand should never be used if it can be at all avoided, as walls built with mortar prepared from it are very likely to be damp. Mortar thus prepared sets very soon on being exposed to the atmosphere, but it is by no means calculated to stand under water, or in very moist and damp situations. Where mortar is required for such work, hydraulic mortar, or hydraulic cement, must be used. The first may be made of *hydraulic limes*, which are found naturally in many situations. The limestones yielding this substance are either argillaceous or magnesian,

or argillo-magnesian. When the proportions of the lime and clay are equal, or vary from forty parts of lime to sixty of clay, or sixty of lime to forty of clay, the lime does not slake under any circumstances, and hardens under water with great rapidity. It is very difficult to distinguish between an ordinary limestone and a hydraulic lime; direct experiment is generally to be resorted to. Hydraulic cements are comparatively easily made, and are on the whole as useful as hydraulic mortars—it is, in fact, a disputed point as to which is the best. The Romans used a mortar containing pounded bricks or tiles, which was valuable for water-works. Clay, burned and mixed with lime, will enable the mortar to withstand to a certain extent the action of water. Where a rich lime is obtainable, a hydraulic lime may be made by mixing twenty parts of dry clay to eighty of the lime. "Puzzolano" cement is made by mixing this substance with lime; it is a volcanic substance of a violet-red colour. Coal-cinders ground to a powder, and mixed with lime, make a mortar which will be useful in wet or damp situations.

Concrete is used for forming the foundations of buildings in bad or yielding soils. It is composed of quicklime well pulverised, sand, and gravel, these being first thoroughly mixed in a dry state; sufficient water being added to bring it to the consistence of ordinary mortar, and rapidly incorporated with a shovel. It should be put into the foundation to be formed while hot—that is, immediately after the thorough incorporation of the materials is effected. A good proportion for the materials is the lime and sand in sufficient quantities to form a good mortar—say two parts sand, one part lime—the gravel being twice the bulk of the sand. For situations where the soil is very damp, a composition called *beton* may be used: this is made with hydraulic mortar (artificial or natural), with fragments of broken brick, stone, or gravel incorporated with it—the fragments not being larger than the size of a hen's egg. As many fragments should be mixed with the mortar as the latter will admit of. An economical beton may be made by a mixture of broken stones or brick with common mortar, having pounded brick incorporated with it (thus making it an artificial hydraulic lime), and of course a fine gravel incorporated with the mass. In making it, the mortar is first incorporated with the finer gravel,

and spread out into a flat surface some 4 or 6 inches in thickness; over this surface the large gravel and broken stones are uniformly strewed, and pressed down, and the whole thoroughly incorporated. Beton may be used in all cases where concrete would be required, and with superior advantages, especially in damp situations. In making concrete or beton, an able authority recommends that the mortar should first be made into a paste before being mixed with the other materials; this insures a better incorporation of the materials.—(*Limes, Cements, Mortars: Rudimentary Treatise*, 1*s.*: Weale. By GEORGE BURNELL.) Fragments of limestone may be mixed with advantage in concretes and betons: the concrete or beton should be laid in regular layers not exceeding a foot in depth, going over all the surface of the foundation regularly before beginning to the second layer.

Cements which harden under water will be useful to the settler. We shall notice a few of these which may be easily made. A very simple kind, which, although not very durable, may be used for coating of roofs, and wood-work exposed to damp, may be made by mixing two parts of sand with one of vegetable tar in a boiling state, and applying this, while hot, to the surface with a brush. Mineral tar is an excellent preservative for wood-work exposed to damp, even when applied by itself; the addition, however, of powdered brick or sand makes it more durable. Mineral tar is obtained by boiling a kind of stone which is strongly impregnated with tar, the earthy matter subsiding to the bottom. Pitch or rosin, with powdered brick, in proportion as above, will serve also as a coating for wood-work.

Many of the argillaceous limestones, when calcined, afford a lime which, when mixed with water in the proportion of one volume of water to two of cement, hardens speedily under water, and adheres with considerable force to stone and iron surfaces, &c. A cement thus made is well known by the name of "Roman." It is made by calcining the "septaria nodules of the London clay formation," and grinding them into powder. An artificial Roman cement may be easily made by mixing two and a half parts of chalk with one of lime, and applying them in the state of a paste, of a consistence easily applied: this will be found useful for lining cisterns, &c. Stone cisterns may be put together with a cement

made of boiled linseed-oil, litharge, red and white lead, mixed together till of proper consistence. The proportion of ingredients may be varied, care being taken not to make the cement too thin. This cement is also useful for joining flanges of iron pipes, &c. Cracks in iron boilers can be stopped up by a cement made by mixing six parts of clay and one of iron-filings, with as much linseed-oil as will make the cement of a proper consistence. Pottery, drain-tubes, and articles of stone, may be fixed with a cement made of seven parts of rosin and one of beeswax, melted and mixed with a small quantity of gypsum, or plaster-of-Paris, or pounded chalk. In cementing such articles as are mentioned, it should be borne in mind, that the thinner the stratum of cement between the two surfaces the firmer will be their adherence. A cement useful for joining glass, &c., and metallic surfaces, is made as follows: "To an ounce of mastic add as much highly-rectified spirits of wine as will dissolve it. Soak an ounce of isinglass in water until quite soft, then dissolve it in pure rum or brandy, until it form a strong glue, to which add about a quarter of an ounce of gum-ammoniac, well rubbed and mixed. Put the two mixtures together in an earthen vessel over a gentle heat; when well united, the mixture to be put in a phial, and well stopped." In using it, the phial must be placed in warm water, to melt the cement; the edges of the glass to be joined should also be warmed. After the cement is put on, the edges should be kept in close contact for at least twelve hours.

A cement well adapted for filling up holes in roofs, stone walls, &c., and which hardens by exposure, is made by mixing up white sand and white lead to a consistence rather thicker than than that of ordinary paint. It may be used for stopping up leaks in cisterns, &c. A cement applicable for the covering of exterior work, lining of cisterns, &c., may be made as follows: Take six parts of burnt clay, one part of white-lead, one part of litharge (red oxide of lead), and three parts of linseed-oil. Vauban's cement for lining cisterns is made by slacking five or six parts of rich lime in linseed-oil, and mixing this up with two parts of cement, passed through a fine sieve. The cement should be well incorporated, and allowed to lie for a night, and beaten up and applied next day. It is to be laid on in thin coats, about $\frac{1}{8}$-inch thick,

some days being suffered to elapse before the succeeding coats are put on. Each coat should be scored, to form a key for the succeeding one. The last coat is of course left smooth.

Limestone may be easily burnt or calcined, where fuel is plentiful, by piling up alternate layers of limestone and coal, coating the sides with clay, and securing as much as possible an equable burning of the whole. This method is, however, very wasteful. Another plan is, to make an excavation in the ground, some 14 feet deep, 10 feet wide at top, and narrowing to about two at the bottom: this may be lined with brick, the coal and limestone being laid in alternate layers. A kiln of this kind will burn 150 bushels in about twenty-four hours. Where coal cannot be obtained, a kind of kiln, similar to the brick-kiln already described, may be used for wood, &c. The walls are to be made of brick, of considerable thickness, not less than four brick-lengths, some 12 feet high, and 12 feet square. Three arches are to be made in one of the walls, about 4 feet high and 2 wide. A species of arch is to be formed of the largest pieces of limestone, one end at the mouth of the opening in side of kiln, and the other reaching to the opposite side: an arch is then to be formed at each opening. The openings in the wall are then to be built up with bricks, leaving spaces near the tops of sufficient dimensions to admit the fuel. The limestone is then to be thrown in at the top, above the arches. In burning lime, the fire must be maintained uninterruptedly until the operation is concluded; the fire once stopped before the lime is properly calcined, the calcination cannot be again effected. Experience can alone dictate as to the exact time required for the proper calcination of limestone. After calcination it falls down, occupying somewhere about a sixth part of its previous volume, and each stone, as it were, crumbling away.

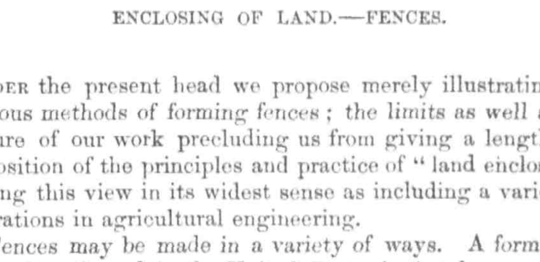
SECTION TWENTY-SEVENTH.

ENCLOSING OF LAND.—FENCES.

UNDER the present head we propose merely illustrating the various methods of forming fences; the limits as well as the nature of our work precluding us from giving a lengthened exposition of the principles and practice of "land enclosure," taking this view in its widest sense as including a variety of operations in agricultural engineering.

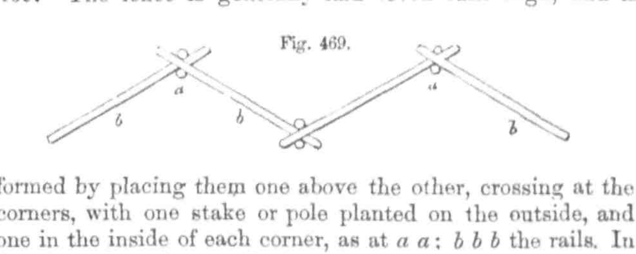
Fences may be made in a variety of ways. A form very generally adopted in the United States is that known as the "zigzag" or "rail" fence. We give an illustration in fig. 469. The fence is generally laid seven rails high, and is

Fig. 469.



formed by placing them one above the other, crossing at the corners, with one stake or pole planted on the outside, and one in the inside of each corner, as at *a a*; *b b b* the rails. In this form the rails are all of one length; in fig. 470 they are

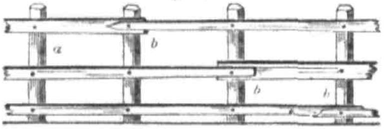
Fig. 470.



of two lengths, *a a a*, *b b*. The common wood-paling may be also used as a fence: we give an illustration of this in

fig. 471. "Stakes, as *a*, should be driven by a mallet 12 inches into the ground at 5 or 6 feet asunder, and where hard, a hole may be made by the foot-pick or the driver; and such stakes will support a paling of 3 feet 3 inches in height. Two rails are sufficient to fence cattle, but three are required for sheep. To give additional strength to the fence, the rails should be nailed on the face of the stakes next the field, and made to break joint, so that the ends of all the three rails shall not be nailed upon the same stake; nor should the broad ends of the rails be nailed together, even though thinned by the adze, but broad and narrow ends together as at *b b b*, that the weight and strength of the rails may be equalised. To make the paling secure, a stake should be driven as a stay in a sloping direction behind the rails, and nailed to every third stake. The upper rail should be nailed near the top of the stakes, the lowest edge of the lowest one 6 inches from the ground, and the upper edge of the middle one 20 inches above the ground."

Fig. 471.



Where branches of trees are plentiful, a form of fence known as the "stake-and-rice" may be easily constructed. In fig. 472, we give an illustration of this. The branches should be made to slope in the direction in which the highest wind generally blows: "*a a* are stakes fashioned from the longer branches of the tops of trees; or, should the tops be too small to afford sufficiently strong stakes, these should be procured from sawn timber, 4½ feet in length, and about 4 inches in the side, and, after being pointed, driven in line into the ground from 4 to 6 feet asunder, according to the length and strength of the tops." Many plants—as the hawthorn—are useful for fences; but into this department it is not our province to enter. Wire-fencing has been much adopted in this country; but as its erection involves the use of material in large quantities not easily obtainable by the

Fig. 472.

settler, we do not intend to offer any illustrations as to its use: moreover, however neat it looks as a fence in the neighbourhood of dwellings, it appears by no means fitted for a useful farm-fence; for high authority thus writes of wire-fencing under these considerations: "They afford no shelter to stock, and appearing insignificant to restless cattle in the fields, have been attempted to be leapt over, and the cattle, not marking the height well, have been caught by the upper wire in the groins, to their serious injury."

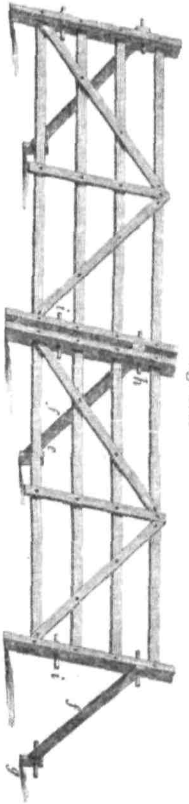


Fig. 473.

Fields may be temporarily fenced into divisions by what are termed "hurdles," as when sheep are turned into a part of a turnip field, &c., &c. We give an illustration of hurdles in fig. 473. "The hurdles are set down in the line of the intended fence. The first hurdle is raised by its upper rail, and the ends of its stakes are sunk a little into the ground with a spade, to give them a firm hold. The second hurdle is let into the ground in the same manner, both being held in that position by the assistant. One end of a stay *f f* is then placed between the hurdles near the tops of their stakes, and the stay and hurdles are fastened together by the peg *h* passing through holes in both. Another peg, *i i*, is passed through a lower part of the stakes. The hurdles are then inclined away from the ground fenced, until their upper rail shall stand 3 feet 9 inches above the ground. A short stake, *e*, is driven into the ground by a mallet, at a point where the stay *f f* gives the hurdles the above inclination, and a peg fastens the stake and stay together as at *g*. After the two first hurdles are set, the operation of fixing the others is comparatively easy.

SECTION TWENTY-EIGHTH.

ROAD-MAKING.

THE roads leading from one part of a farm to another are generally formed by cutting a mere strip of land a few inches below the level of the surrounding ground, attempts at forming a hard substratum to insure the durability of the road being rarely carried out. In many of the new settlements of the United States, what is termed "a corduroy road" is generally made use of. This is formed of trees cut up longitudinally, and laid transversely on the previously-prepared ground, the rounded sides upwards. A species of tram-road, infinitely in advance of this rude contrivance, is what is known as the plank-road. Where lumber is plentiful, we would recommend the settler to lay down a road of this kind, especially in parts of his farm on which there is much traffic. The line of road is first to be marked out, and its breadth staked off, the hollow places being filled up with the material taken from the cuttings, and embankments made where necessary. The cross section of the road should be convex—that is, higher in the middle than at the sides—leaving a hollow on each side, into which the water may run off from the planks through small holes or drains. A track little broader than the breadth of a coach or waggon (if for a single line) is marked out; and on each side of this, planks some 8 or 9 feet long, 8 inches broad, and 3 thick, are laid parallel thereto. These are laid end to end, thus forming a double line of planks along the road. On the top of these side-supports, the planks on which the carriages run, forming the roadway, are laid; these project a little beyond the side-supports: they are generally some 10 or 14 inches broad, and 2 or 3 thick. The side of the embankment is brought up so as to cover the ends, and the road is complete.

We do not deem it at all necessary to go into detail as to the methods adopted for laying out a road, so as to secure the most beneficial level, and the nearest route, between any two desired points; for all purposes of the farm, the settler will at once be able to distinguish at what points a hollow place may be filled up, and embankments made from the material obtained from cuttings, and the cases in which the trouble and cost of performing these operations would be repaid by the extra perfection of the road. We shall merely content ourselves with a few hints as to the form of roads, and the kind of materials which may be adopted, leaving the reader to decide, according as circumstances or his own opinions may dictate, as to which of these he may carry out in practice.

Convex roads—that is, roads highest in the centre—have been much recommended, from the facilities which the form presents to the thorough drainage of the surface; the water, it is said, freely running from the centre to the sides. Authorities, however, seem to agree in thinking that the advantages of this have been much overrated. The principal objection made to it is, that as the centre of the road is the only place at which the vehicles passing over it can be kept vertical, it is most frequently used; and hence the centre part becomes hollow, affording a receptacle, as it were, for rains to lodge in, and from which it is difficult to run off. Upon the whole, we would recommend the settler to form the road nearly flat across its breadth, and if with a rise in the centre, that it should be very slight. The materials of which to make a good road-surface may be broken stones, of a size sufficient to pass through a ring 2 inches diameter. These are placed in layers on the road, and well rammed down; the upper surface soon becomes smooth and consolidated by the action of the passing vehicles. Some recommend the depth of materials to be greater in the centre than at the sides of the road; this, however, should not be attended to: on the contrary, care should be taken to make all portions of the road equal in construction and solidity—the aim in a well laid-out road being to make it serviceable on all parts of its surface for the passage of vehicles. When side-walks are required, they may be formed of a layer of broken stones of size sufficient to pass through a ring 1 inch diameter, with

two layers of gravel well rammed down: the surface should slope towards the side drain. In place of ramming the broken stones on the soil which forms the basis of the principal road, blocks of rough stones may first be laid down, and the layers of smaller stones above these. Good gravel is a good material for road-surfaces.

In all cases drains should be made at the side (or both sides if possible), by which to carry off the surface-water. These drains are formed by ditches of sufficient depth to carry away the water, and having a proper fall throughout their length. Where a footpath is made, the surface-water of the main road, and that of the footpath, is taken off by a small gutter formed at the inner edge of footpath, and constructed of blocks of stones: small outlets are made at intervals by which the water is led off through drains placed beneath the footpath to the large side drain or ditch. Where the side ditch or drain is of sufficient depth, the soil beneath the road-surface will also be drained by it.

In excavating roads, the sides of the excavation should have 2 feet of a slope outwards for 1 foot perpendicular of its height. If a top surface-drain or small ditch is made at the top of the excavation, within a few feet of its edge, the surface of the slope will be rendered comparatively dry. This top-drain runs parallel to the road. Where the soil is sandy or gravelly, a greater degree of slope must be given to the sides of the excavation. In forming embankments, each layer, of some 4 feet, should be well rammed; this tends to consolidate the road. The slope given to the sides should be less than that which the materials would naturally assume if left to themselves. The side slopes can be very efficiently protected by encouraging the growth of grass on them. The surface-water from the road must not be allowed to run down the sides, but be carefully let off by properly-constructed side-drains.

Where a road is formed over a sandy soil, the sand may be in a great measure prevented from shifting laterally by digging, at each side of the road, ditches some 30 inches deep, and same wide—filling these up with turf or clay, and ramming them well. This precaution need not be taken where an excavation and strong embankments are made in the sides.

Where the soil is a strong retentive clay, the drainage of the under-surface of the road will be best provided for by cutting a trench in the centre of the road (before the surface materials are put in), about 2 feet deep, forming a stout drain on this, and sloping up the sides of the trench to a breadth three or four times the width of drain, and filling the trench with broken stones, and thereafter finishing the road-surface as already detailed.

In forming a road over a boggy or marshy soil, a simple method may be carried out as follows: Make deep ditches at each side of the intended road, to draw off the water from the part cut out to receive the surface materials. Level the surface intended to receive the road materials, filling up the hollows with sods carefully rammed down; then make a foundation of furze, heath, or broom branches, and above these proceed to lay the upper road-materials. A firmer foundation, however, will be made by making side trenches, 30 inches wide and deep, filling these with well-rammed clay or turf—the distance between these corresponding to width of intended road. The space between these, to a depth of 12 inches, is to be filled up with gravel or coarse sand well rammed down; and, finally, if considered requisite, provided with one or more layers of broken stones.

SECTION TWENTY-NINTH.

WELL-SINKING.

Under this head we must confine ourselves to explaining the easiest method of sinking shafts for wells in various soils, refraining from noticing the method of obtaining water by boring through the surface and the various strata, this involving the use of instruments and appliances not easily attainable by the settler. It is somewhat difficult to decide as to the localities most suitable for sinking a well, so as to insure a regular supply of water at a reasonable depth. Mr Swindell (*Rudimentary Treatise on Well-digging and Boring*—1s. Weale: London) gives the following as a few simple directions on this point. "In the early part of the year, if the grass assume a brighter colour in one particular part of a field than in the remainder, or, when the latter is ploughed, if a part be darker than the rest, it may be suspected that water will be found beneath it. In summer, the gnats hover in a column and remain, always at a certain height above the ground, over the spots where springs are concealed. In all seasons of the year more dense vapours arise from these portions of the surface, from which, owing to the existence of subterranean springs, a greater degree of humidity gives rise to more copious exhalations, especially in the morning or evening. The springs to which these rules apply are such as are only near the surface." In trap-rock, water is not likely to be found; and in gravel, sand, or rich unctuous clay, digging to a considerable depth will likely be required before water is obtained. Water is most certain to be found in diluvial clay: this, although impervious to water, is here and there intersected with veins of sand, interspersed with small stones, on removing which water is found to ooze, and which may be collected in a pit formed in the clay. The following is the method of digging

a well in such a soil, as recommended by Mr Stephens: "Let a circle of 8 feet in diameter be described on the surface of the ground, from whose area let the surface-soil be removed to be used elsewhere as compost. After throwing out a depth of 8 or 9 feet with the spade, let a winch and rope and bucket be set up to draw the earth out of the well. While the digging is proceeding, let a sufficient quantity of flat stones be laid down near the winch, by which to let them down to build the ring. A depth of 16 feet will most probably suffice; but if no water is found, let the digging proceed to the requisite depth. A ring of 3 feet in diameter will be a large enough bore for the well: the rest of the space should be filled up with dry rubble masonry, and drawn in at the top to 2 feet in diameter. Whenever the building is finished, the water should be removed from the well with buckets if the quantity is small, and with a pump if it be large, to allow the bottom to be cleared of mud and stones. A thick flat stone, reaching from the side of the ring to beyond the centre, should be firmly placed on the ground at the bottom of the well for the wooden pump to stand upon, or for the lead pipe to rest on. If a wooden pump is used, a large flat stone, having a hole in it to embrace the pump, should be laid on a level with the ground upon the ring of the well; but if a lead pipe is preferred, the flat stone should be entire and cover the ring, and the *clayey* earth thrown over it."

In cases where the well has to be sunk in loose gravel or sand, a different plan has to be adopted. The following is a specification of a method (given in *The Book of the Farm*) carried out by Mr Wilson, Dumbartonshire, successfully: "The diameter of the well to be 3 feet 6 inches inside of the building, and the building, instead of rubble, to be of droved ashlar, each stone 8 inches broad in the bed, 12 inches deep, about $21\frac{2}{3}$ inches long, in the chord of the arc of circle on the one side, and 17 inches long in a straight line on the other side. The outside of the stones to be formed neatly to a circle, and their inside into an octagon. Beds to be square; ends properly bevelled and wrought correctly to a mould; each course to contain 8 stones of equal size; a ring-board to be formed of willow, not to taste the water, $8\frac{1}{2}$ inches broad, $1\frac{1}{2}$ or 2 inches thick, and $\frac{1}{2}$-inch larger than the outside circle of the stones. The ring-board could be made stronger

in two courses of four pieces of equal size. In building upon the ring-board, the first course of stones to have the centres of their face raised perpendicular to the inside of the ring-board. The centres of each stone of the second course to be placed over the joints of the preceding course, and also perpendicular to the inside of the ring-board. The inside face of each stone being a straight line, the inside diameter of the well being $3\frac{1}{2}$ feet, and the ring-board being correctly made, the inside ends of each stone will be back $1\frac{2}{3}$ inch from the centre of the face of each stone in the course immediately above it, and so on with every course. A small stick made as a gauge at one end, of $1\frac{2}{3}$ inch length, will be found handy for setting the stones. The outside circle must be most carefully made. The upper course to form a square instead of an octagon for the covers to rest on, and to slope to one side, to carry the water off the top of the well. The covers to be droved, and in three pieces, one of which to cover the building on one side and half of the well, and to be half-checked where the other two stones meet it in the middle, and they are to be half-checked into it, also half-checked into each other where they meet in the middle, and to cover the other side of the building. One of the stones covering a portion of the well to have an iron ring in it, by which to lift it freely out of the checks of the other two stones. The joints of the covers to be filled with putty well mixed with white-lead, to prevent water from the surface getting into the well."

The method of sinking the well is thus described by Mr Wilson: "I had the stones dressed, droved to a mould as specified, and all ready before breaking ground, when I made a rod 2 inches longer than the extreme diameter of the ring-board; described the circle on the surface with it, and gave it to the labourer as a gauge, that he might not take out any more sand and gravel than was necessary to let the ring-board in with ease. I had about 5 feet of gravel, which I should always like to go through before laying in the ring-board. There were then 2 feet of fine sand, when water appeared by taking a shovelful out of the centre. I then ordered the ring-board to be put in and levelled, and built upon to the top of seven courses, filling up as it was built the back of each course with fine sand, loosely put in with a

shovel, to steady the building when sinking. I then commenced taking gravel out of the centre with a short shovel, and a bucket with a rope attached to it to be drawn up with a winch and handle. In about three hours of an afternoon there was about a foot of water. Next day I commenced taking out a barrowful of sand, and two or three bucketfuls of water alternately, till in other three hours I had got down altogether about 11 feet 6 inches, when the water flowed in so much that I could not proceed further, and it rose to its level of 3 feet 8 inches. The building went down steadily, and did not seem to be an eighth of an inch off the level at which it was first set. Other four courses were then built, and the covers put on, and the pump-frame erected several feet from the side of the well, where an inclined plane and gutter had been formed to carry off the water. The pump I use is a copper chamber, 4 inches in diameter, with brass boxes, and a 2-inch lead pipe attached to the chamber, and laid into the well through the side of the building about 2 feet below the surface."

From this description hints of value will be obtained, in sinking a well under similar circumstances.

Where the interior of the well is faced with bricks—"steined" as it is termed—a simple method of proceeding is as follows: A dram-curb is provided, being a circular frame of wood, with a strong flat ring, of the same diameter as the intended well at top and bottom, the breadth of the ring being equal to the breadth of a brick; the depth of curb is 5 feet or so. The ground being excavated to a depth equal to that of the curb, this is lowered into the excavation. The operation of digging is continued, the curb gradually descending—the excavated earth being removed by buckets lifted by tackle supported above the excavation by a triangular frame. The steining or brickwork is then built on the upper ring of the curb; the bricks are laid without mortar, care being taken to arrange them so as to keep the form of the circle as perfect as possible, each course breaking joint with the one under it. As the sinking of the curb goes on, the laying of the bricks is proceeded with, until the necessary depth is obtained. It is scarcely requisite to point out the absolute necessity of making all wells circular;—the sides of square ones would inevitably be forced in.

Of all the methods in use for raising the water from the wells, the ascending and descending buckets (the empty one descending as the full one is being pulled up) form the simplest. The buckets must be comparatively heavy to allow of their sinking into the water on being let down. The rope to which the buckets are attached is wound round a wooden barrel, revolving on two uprights at each side of the well mouth, and turned by a winch or handle. The well-covering should be made in two halves opening upwards, and hinged at the outer edges to a wooden frame placed round the mouth of the well. A small space should be left between the edges of the flaps, to admit of the rope passing freely. A small curb-wall should be made round the mouth, in order to prevent surface-water running into the well; and a railing, some 3 or 4 feet high, to prevent children having access.

SECTION THIRTIETH.

FARM AND AGRICULTURAL BUILDINGS.

In the present division of the work we purpose giving plans and suggestions of the various structures so necessary to be appended to farmhouse—as barns, stables, cowhouses, piggeries, &c. &c. While presenting plans, offering hints as to the methods of concentrating them, so as to throw them as much together as possible, saving labour and expense in constructing—as roofing, &c.—and affording numerous conveniences in close connection one with another, we shall also give the various structures in separate plans, thus enabling the reader to comprehend their various details of construction and arrangement.

The structure of which we shall first treat is the "barn." This word has a more extended import when applied to agriculture as practised in the United States, especially in the northern and middle states, than it bears in this country. Here it is usually applied to distinguish the apartment in which the grain is placed, and the thrashing and preparatory processes are gone through. In America, generally, it implies a number of arrangements under one roof—as stables, cattle-sheds, granary, &c. The best examples of American barns are said to be in Pennsylvania. The following remarks on this department of farm-buildings are so apposite, that we deem their insertion will be useful to the reader—they are those of a practised American agriculturist, Mr Allen: "In the structure of the barn and its interior accommodation, much will depend upon the branches of agriculture to which the farm is devoted. A farm cultivated in grain chiefly, requires but little room for stabling purposes—storage for grain in the sheaf, and granaries, will require its room; while a stock-farm requires a barn with extensive hay storage, and stables

for its cattle, horses, and sheep—all climates not admitting such stock to live through the winter in the field, like the great grazing states west of the Alleghanies. Again, there are wide districts of country where a mixed husbandry of grain and stock is pursued, which require barns and outbuildings accommodating both. . . . . In the arrangement of the building, another item to be considered is the comparative value of the stock, the forage fed to them, and the labour expended in feeding and taking care of them. We will illustrate. Suppose a farm to lie in the vicinity of a large town or city. Its value is perhaps a hundred dollars an acre. The hay cut upon it is worth fifteen dollars a ton at the barn, and straw and coarse grains in proportion, and hired labour ten or twelve dollars (a dollar is worth 4s. 2d.) a-month. Consequently the manager of this farm should use all the economy in his power, by the aid of cutting-boxes and other machinery, to make the least amount of forage supply the wants of his stock, and arrange the internal economy of his barn accordingly, because labour is the cheapest item, and food the dearest; therefore every contrivance to work up his forage the closest, by way of machinery or manual labour by which it will serve the purposes of keeping his stock, is true economy—and the making and saving of manures is an item of the first importance. His buildings, and their arrangements throughout, should, on these accounts, be constructed in accordance with his practice. If, on the other hand, lands are cheap and productive, and labour comparatively dear (as in the western states), a different practice will prevail. He will feed his hay from the mow without cutting. The straw will be either stacked out and the cattle turned to it to pick what they like of it, and make their beds on the remainder; or if it is housed, he will throw it into racks, and the stock may eat what they choose. It is but one-third or one-half the labour to do this that the other mode requires, and the saving in this makes up, and perhaps more than makes up, for the increased quantity of forage consumed. Again, climate may equally affect the mode of winter-feeding the stock. The winters may be mild. The hay may be stacked in the fields when gathered, or put into small barns built for hay alone; and the manure scattered over the fields by the cattle, as they are fed from either of them, may be

knocked to pieces with the dung-bettle in the spring, or harrowed and brushed over the ground; and with the very small quantity of labour required in all this, such practice will be more economical than any other which can be adopted. It is therefore a subject of deliberate study with the farmer, in the construction of his outbuildings, what plan he shall adopt in regard to them, and their fitting-up and arrangement." The following is the plan of a barn recommended by Mr Allen, designed partially on the Pennsylvania plan, with underground stables, and a stone-walled basement on three sides. A line of posts stand at *x*, fig. 474, and a wall *e e* placed backwards from these, thus affording space for cattle-sheds. Two sheds *o o* for cattle-shelter can be run out to any desired length, at right angles to *e e*. The barn is built on sloping ground, so as to admit of the under portion being made without much excavation. Fig. 475 is the main floor of the barn; its dimensions are 60 feet by 46; two large doors are at the end, 14 feet square—a louvre boarded window being above these. A door, 9 feet by 6, opens towards the yard from the apartment *F*. The main floor *A h h*, 12 feet wide, runs along the whole length of the barn; *h h* are trap-doors to let forage down to the stables beneath; *B* is the principal bay for hay, 16 feet wide, running up to the roof; *G* is the bay, 26 feet by 16, for the grain—more if required for that purpose; *D* the granary, 13 feet by 16 feet by 8; *E* a storage-room for machinery, &c.;

Fig. 474.

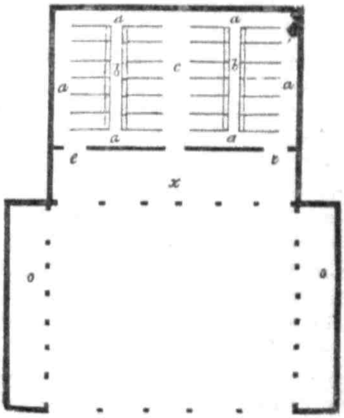
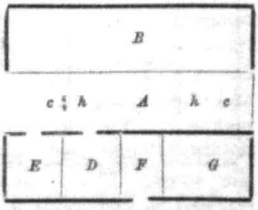


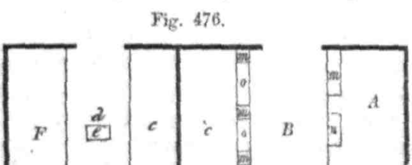
Fig. 475.



F a passage from main floor *A h h* to door leading to yard. Grain in the sheaf, or hay, may be stored in the space above *F D* and *E*. The main floor will accommodate the thrashing-machine, &c., when at work. "A line of movable sleepers or poles may be laid across the floor, 10 feet above it, on a line of girts framed into the main posts for that purpose, over which, when the sides of the barn are full, either hay or grain may be deposited up to the ridge of the roof, and thus afford large storage; and if the demands of the crop require it, after the sides and over the floor is thus filled, the floor itself may, or part of it, be used for packing away either hay or grain." The stables, &c., are placed beneath the body of the barn, as seen in fig. 474; it is here cut up into stables. Passages *a a a a a a* are made for the stock to go into the stalls: *c* is the centre passage, 8 feet wide; *b b* the passages, 3 feet wide, between the mangers placed under the traps *h h* in the main floor. The mangers are 2 feet wide; the stalls are 6½ feet wide; at the end walls the cattle passages are 5 feet wide, the partition between the stalls being sloped from 5 feet high at the upper end down to the floor. The main floor is provided with inclined planes leading from the surrounding level to the main doors: this will be found a great convenience in housing hay, &c. The sheds *o o* may be used for carts, &c., or shelter sheds: there may be storage room for hay, &c., made over them.

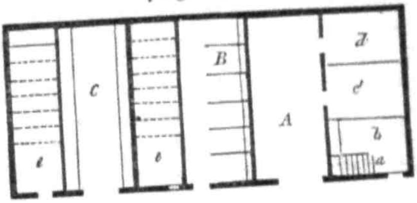
Mr Downing, in his excellent work, *Country Houses*, published in New York—gives a plan of a barn, the design of Mr Sayer of Newbury, New York, which is worthy of attention. We give in fig. 476 the plan of main floor, and in fig. 477 the plan of basement. The dimensions are 30 feet by 72. In fig. 476, *d* is the main floor, 12 feet wide, with hay bays or mows on each side, as *c F*; a trap-door *e* is made in floor to pass through hay to the cowhouse beneath; the thrashing-floor is at *B*, with a grain mow *A* on one side, and a hay mow *c'* on the other. Through the space *n* straw is thrown

Fig. 476.



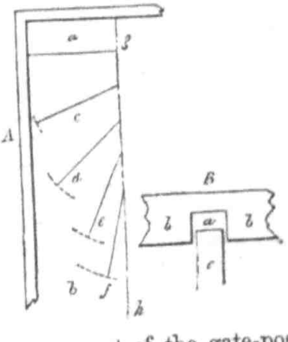
lown to the straw-room; through the other spaces, *m m m m*, roots are thrown to the root-cellar in the basement; through the spaces *o* in *c'* the hay is passed down to the mangers of the stable. In fig. 477, the basement plan, *c e e* is the cow house, stable, or byre, 30 feet square; the feeding-passage, including the mangers, is 11 feet wide; there is accommodation for 18 cows.

Fig. 477.



The manner in which the cows are housed is quite novel, and possesses some points worthy of consideration. In fig. 478 the divisions between each stall consist of a light gate swung on posts at the side of the manger, as on the line *g h* in *A*; on the first cow entering at *b* it walks up towards the head, and placing herself at *a*, the attendant shuts the gate; the next cow enters, and the gate *c* is shut; the same is done with *d e* and *f*, the space between two gates forming a stall, the heads of all the cows being towards the mangers.

Fig. 478.



The gates are not hung with hinges, but as in *B*, where *c* represents the upper part of the gate-post turning in a hole in the cross-beam *b b*. The gate, when resting on the bottom rail, allows a space above it, as *a*; when it is wished that the gate should be removed—as when a stall is required of double the usual space, when a cow is calving—the light gate is lifted upwards, and its post going into the space *a*, the foot is relieved from its turning-point, and the gate is thus easily removed. *B*, fig. 477, is the stable, 14 feet wide; *A* is the carriage-house; the root or turnip cellar is at *d*; *c'* a place for straw, &c.; *b* a spare stall or infirmary. In *b* the stairs *a* are placed by which to gain access to the main floor.

For many farms, the arrangements already given will be of

sufficient compactness and extent—some of the buildings, as piggeries, being detached; but we now propose to give a few illustrations of farm-buildings on a larger scale, and in which all the necessary buildings are comprised. In fig. 479

Fig. 479.

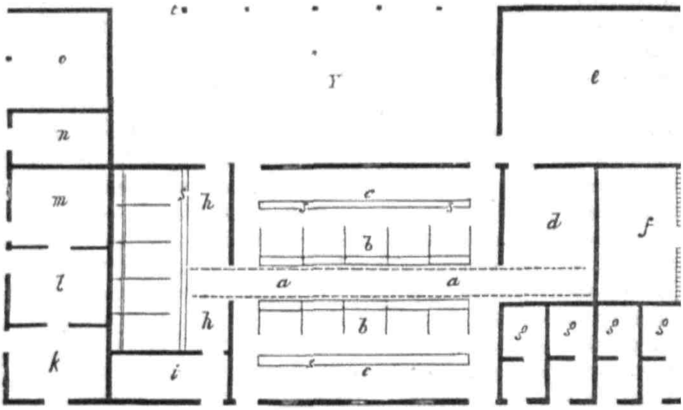
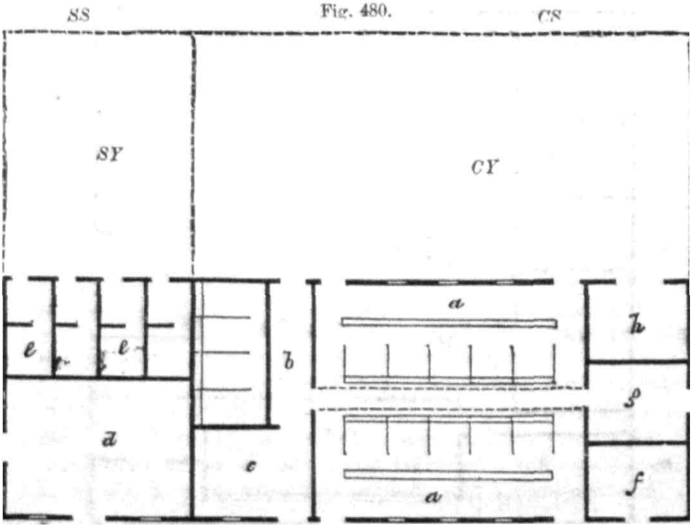
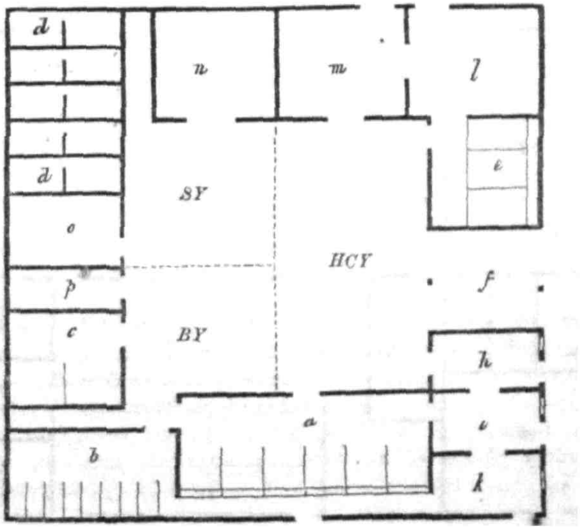


Fig. 480.



we give a plan suggestive of the arrangements, which may be modified: the cowhouse is at *c c*; *b b* the stalls; *s s*, *s*, *s* gutters leading to the "liquid-manure tank" in the yard; the "root-store" is at *d*; the roots are taken to the cowhouse and stable by a track-way leading between the feeding-troughs, as shown by the dotted lines *a a*; the machine-room *e*, with granary over; *f* the poultry-house; *g g g g* pig-houses; *h h* cart-horse stable; *i* harness-room; *k* milk-room; *l* scalding-room; *m* cheese-room; *n* carpenter and tool shop; *o* cart-house; *Y* yard; *t* railing or posts forming front of shelter-sheds opening out to yard, which may be constructed outside of line *t*. In fig. 480 we give another plan of farm-buildings: *a a* the cow-byre; *b* the cart-horse stable; *c* the boil-house for preparing washes, or it may be used as a harness-room; *d* machine-room, granary over; hay storage over cowhouse, stable, and boil-house; *e e* piggery; *f* hen-house; *g* root-house, with track-way leading from this between the mangers of cowhouse to the stable *b* and boil-house *c*; *h* carpenter's shop and tool-house; *C Y* the cattle-yard; *S Y* the sheep-yard, cattle and sheep shelter-sheds being placed outside of the line *CS*, *S S*; entrance-gates are placed at *E E*. Fig. 481

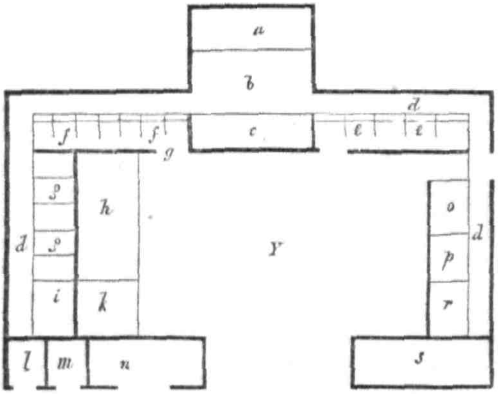
Fig. 481.



is a plan in which the yards are surrounded by the various buildings: *a* the cowhouse, *b* the calf-shed, *c* the bull-shed, *d d* piggery, *e* stable, *f* cart-house, with entrance to yards through *g*; h tool-house and carpenter's shop, *i* boil-house, *k* root-house, *l* barn, *m* granary, *n* sheep shelter shed, *o* poultry, *p* rabbitry, *H C Y* horse and cattle yard, *S Y* sheep-yard, *B Y* bull-yard. In fig. 482 we give the scale to which figs. 479, 480, and 481 are drawn. In fig. 483 we give plan of farm-buildings adapted for the northern states of America, United States. We are indebted for this to Mr Marshall's book, *The Farmers' and Emigrants' Handbook*, published by Appleton, New York—a

Fig. 482.

Fig. 483.



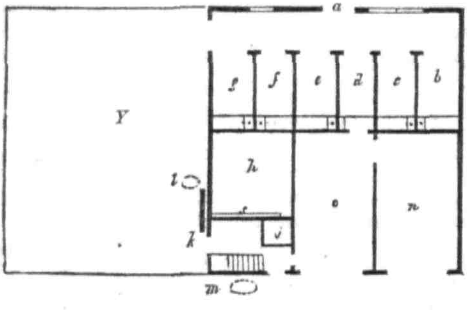
work containing a large amount of recipes and directions for rearing and breeding of stock, &c., useful to the emigrant farmer: *a* space for roots, being filled through two windows provided with hopper-like troughs, through which the roots are tilted; *b* machine-room for cutting straw, roots, &c.; c straw bay, *d d d* passage behind mangers of cowhouse *e e*, and stable *f f*, *g g* sheep-shed, with racks at right angles to the passage *d*; *h* sheep-yard, *i* piggery, with yard *k*; *l* poultry-house, *m* boil-house, *n* store for firewood, wood being much better when stored up for a few years; *o* calf-

house, *p* carpenter's shop, for tools, &c.; *r* implement-house; *s* waggon-shed; *Y* the yard. We have slightly altered the plan, securing what we consider more uniformity of arrangement than is given in the original.

In the southern and western states of America the peculiarities of farming, as there practised, require several modifications of arrangement, &c., in the farm-buildings, differing from those carried out in the northern or middle states. Professor Turner of Illinois has made public a variety of useful hints on stables and farm-buildings for the West, a portion of which will, we think, be highly useful to our readers. His remarks are given *in extenso* in Mr Downing's *American Country Architecture*. "Throughout the vast regions devoted to stock, especially in Illinois and Missouri, and all the states south of these, stables are used not for sheltering common stock or fodder, but merely for the few horses and milch-cows which are kept for family use. Many farmers in these states annually fatten some one or two hundred head of oxen, and some few even a thousand or more, for the market, and still a very moderate-sized stable, or rather no stable at all, answers their purpose." Mr Turner then gives a statement of what "ends the great majority of those who are intending to build in those regions wish to reach," the purport of which we give as follows: Wood (or *lumber* as it is called) being very dear in the West, as also labour, economy in these is the first consideration. This is best effected by throwing all the buildings under "one roof, and in a square form, or one as nearly square as possible; the foundations, made of brick or stone—and which may have to be transported from a distance at great cost—will, by the same plan, be also economised." Another desideratum, and one peculiar to these states, is to have "free access to and from their outbuildings, without passing through the terrible mud and water which, in prairie countries, always exists on all flat lands where cattle or swine are yarded, or allowed to run in small lots. Those who are accustomed only to a rocky or gravelly soil, can form no adequate conception of the inconvenience of the prairie mud throughout all the rainy seasons of the year." The location of the well is a point of great importance, as water is not found in springs or brooks, but from wells. The conveniences on the stable are, stalls for from one to four

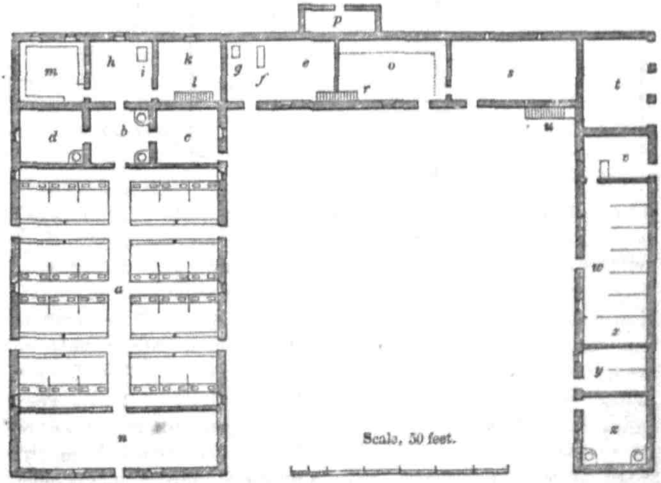
horses, ditto cows (though sheds are generally used for the latter), pig and fowl house, carriage and tool house. Room for storing hay is also useful, though this crop is chiefly stacked, and the corn "cribbed" in the fields. Room will, however, be required for storing as much of these crops as will suffice for the provender of the stock. Professor Turner gives a plan illustrative of the arrangements proposed: this we now append. At *a*, fig. 484, a door is made in the rear of the cattle-stalls *b c d e f g*, through which to pass the manure from time to time; *h* is the corn-crib. The floor of this, as well as the corn-cribs in the stalls indicated by the small black circles, should be from 2½ to 3 feet above the level of the ground, so as to admit of the pigs getting beneath them. By this arrangement, not only will shelter be provided for them, but they will be enabled to pick up all scattered corn, and also prevent rats from accumulating, as they will be prevented from depredating by the continual intrusion of the pigs. The front of one stall should be open, to admit of a door being made, so as to give access to the stalls from the carriage and waggon houses *n o*. As the weather in the West is at times very cold, the well should be located in a convenient recess, as at *j*; the water should be supplied to the trough *k*, in the yard, through a spout *s*. Two troughs should be made here, one higher than the other, the lower one being for the use of the pigs—these animals being, in Western farming, allowed to follow the larger stock in the yard. A small pond *l* receives the water from the troughs, and is used for ducks, &c.; another pond *m*, outside the yard, is used for goslings and ducklings. In selecting a place for the building, the yard should be on the east side, and a green grass surface on the south side of both stable and stock-yard *Y*, no cattle or

Fig. 484.



hogs being allowed to pass in to the grass; so that the farmer may have a mudless access at all times to the farm-buildings. The ground should, if possible, be selected sloping, the stable at the highest part, so as to allow the wet to go towards the lower end of the yard. If sloping ground cannot be obtained, an artificial slope should be made. The position of the well *i* will, of course, dictate the other arrangements, the well being first dug. The stables can be constructed as already explained while treating of frame-houses. Mr Turner recommends the inside to be boarded up, and the space between to be filled up with sawdust or powdered clay, to keep the interior dry and warm. As forming suggestive illustrations, from which our readers will derive useful information, we here append plans of a "dairy" and a "sheep"

Fig. 485.



farm-steading. They are given by Mr Stephens in his *Book of the Farm*, and are more peculiarly adapted for farming as practised in this country, but will doubtless convey many hints valuable for the colonies, &c. In fig. 485 we give the plan of dairy farm: *a* the byre or cowhouse, *b* the boil-house, *c* the root-house, *d* apartment for washing and drying dairy utensils (in this a boiler is placed for heating water or milk);

m is the milk-house, shelved round; *h* the churn-house, *i* the churn, *k* salted butter and utensils apartment, *l* stairs leading to the cheese-room above, which extends over *m*, *h*, and *k*; *g* the corn-bruiser; *f* the hay-cutter, (turnips and uncut hay are kept in the large apartment *n*); the corn-barn is at *o*, situated immediately below the thrashing-machine, which in this case is supposed to be driven by the water-wheel in *p*; *r* is the stair leading to the granary above the apartment *e*; the straw-barn is at *s*; *t* is the cart-shed, giving accommodation to six single horse-carts; the outside stair *u* leads to a second granary above the cart-shed; *v* hay-house for the work-horses—in this is the horse corn-chest, and it has a communication with the work-horse stable *w*, giving accommodation to six horses, with a loose-box *x*; *y* is the riding-horse stable, *z* an apartment containing two boilers, one for preparing food for the horses, the other that for the pigs, &c. The piggeries, and byre for young heifers brought up to renew the stock, may be erected at convenient places.*

Fig. 486.

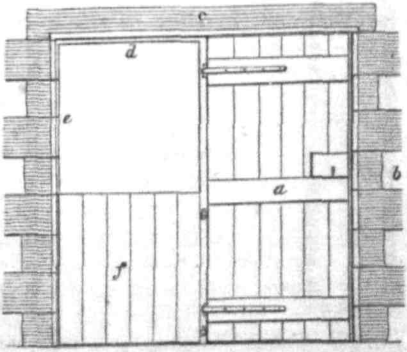
In fig. 486 we give the plan of the farm-steading of the arable part of a sheep farm. "It is not easy," says Mr Stephens, "to determine the proportion which the arable land should bear to the pastoral, to supply all the necessaries; but perhaps two acres arable to every twenty breeding ewes may suffice." The north range of building stands east and west, and comprehends a cart-shed *a*, 18 feet square; gig-house *b*, 10 feet by 18; corn-

* *Book of the Farm*, new edition, vol. ii. p. 289, fig. 384.

barn *c*, 32 feet by 18; with chaff-house *d*, straw-barn *e*, 40 feet by 18 on the ground, with granary above the implement-house, cart-shed, and gig-house; and upper barn over the corn-barn, with a door for taking in the grain in sheaf, by the side of the horse-course *p*, which is 26 feet in diameter. The east wing is 18 feet in width, and contains the cart-stable, 32 feet by 18, fitted up with a loose-box *f*, and 4 stalls *g*, 6 feet wide; a hay-house *h*, 10 feet by 18; riding-stable *i*, 12 feet by 18; and boiler-house *o*, 15 feet by 18, with a boiler and furnace in the gable. The west wing is also 18 feet in width, and contains an implement-house *k*, 18 feet square; a cow-byre *l*, 25 feet by 18, having five stalls of 5 feet each; an outhouse *n*, 12 feet by 18, for weighing the wool in, and doing anything to the sheep; and a wool-room *m*, 34 feet by 18, (the apartments may be made larger or smaller, to suit the extent of the farm); *r* is the pump-well.*

We now proceed, as already arranged, to give separate plans of the various conveniences, showing the details of their arrangement and construction. Straw-barn doors should not be divided vertically into two leaves, as is usually done, but horizontally—the lower being always kept shut, to prevent pigs, &c., from entering. Light should be admitted to the straw-barn by a skylight, if possible, to enable the men to stow it carefully away. The floor should be paved, if possible, but at all events of a hard dry nature, to prevent damp rising. Blocks of hard wood should be inserted into the ground at the place where the straw passes down from the thrashing-machine, or strongly boarded. This resists the action of the forks, in taking up the straw. The height of the corn-barn should not be less than 9 feet. Two windows should be provided at least. In fig. 487

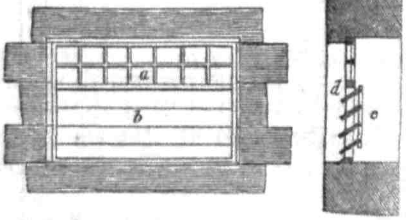
Fig. 487.



* *Book of the Farm*, new edition, vol. i. p. 229, fig. 55.

a is the inside form of a corn-barn door, mounted on crooks and boards, fully open, and thrown back into the recess of the wall *b*, the projecting part of the lintel *c* protecting it effectually from the rain; *d* is the giblet-check in the lintel, and *e* that in the rebates, into which the door shuts flush; *f* is the light movable door, used when work is going on in the corn-barn.* The floor of the corn-barn may be a mortar one (see FLOORS), but a boarded one is best. A dry floor is indispensable, and a wooden one is the only one in which dependence for this desideratum can be placed. A very excellent plan of making a floor of a corn-barn, and an effectual preventive of decay, from the ravages of rats, &c., is given by Mr Stephens, in *Book of the Farm*, vol. i. p. 377, which, from the limits of our work, we are unfortunately prevented from here illustrating. In fig. 488 we give elevation and section of granary windows. The opening is $4\frac{1}{2}$ feet in length by 3 in height. In the frame *a* are two rows of glass panes and Venetian shutters *b*; *c* shows in section the manner in which these shutters operate. They revolve by their ends (a round pin) in holes in the side-posts of the frame *d*, and are kept in a parallel position to each other by the bar *c*, which is attached to them by an eye of iron moving stiff on an iron pin passing through both the eye and the bar *c*. †

Fig. 488.

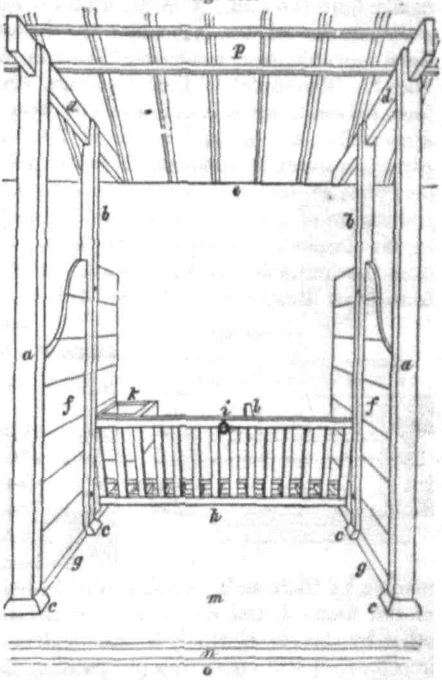


In the construction of *stables*, the size of stalls should be duly considered. Mr Stephens is of opinion that the width of stall should not be less than 6 feet from centre to centre of travis. In a stall of this size a work-horse can stand at his ease, or lie down at pleasure—a facility for doing this being of the utmost importance to the maintenance of his health and vigour. Mr Stephens gives a drawing, which we here append, of a stall for a work-horse stable, in which the arrangements are calculated to render the animal as comfortable

* *Book of the Farm*, vol. ii. p. 376. † *Ibid.*, vol. i. p. 279.

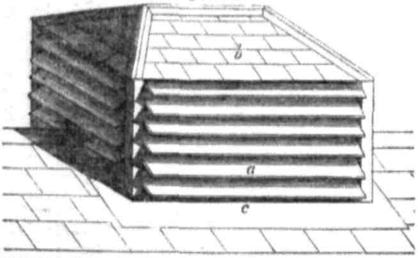
as possible. In fig. 489 "*a a* are the strong wooden hind-posts, *b b* the head-posts, both sunk into the stone blocks *c c c c*, and fastened to the battens *d d*, stretching across the stable from the wall *e* to the opposite wall; *f f* the travis-boards, let into the posts *a a* by grooves, and passing between the two divisions of the posts *b b*, (the boards are represented high enough to prevent the horses annoying each other); *g g* are curb-stones set between the hind and fore posts *a* and *b*, to receive the side of the travis-boards in grooves, and thereby secure them from decay by keeping them above the action of the litter; *h* is the sparred bottom of the hay-rack, the upper rail of which holds the ring *i* for the stall collar-shank; *k* the corn-manger or trough, *l* the bar across the rack, to prevent the horse tossing out the fodder; *m* the pavement within the stall; *n* the freestone gutter for conveying away the urine to one end of the stable; *o* the pavement of the passage behind the horse's heels; *p* two parallel spars fastened over and across the battens, when there is no hay-loft, to support trusses of straw or hay, to be given as fodder to the horses in the evenings of winter, to save the risk of fire in going at night to the straw-barn or hay-house with a light." The floors of stables should be made hard—causeway

Fig. 489.



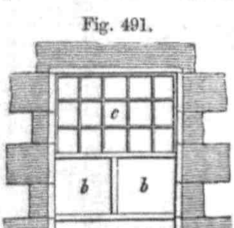
probably forms the best. The floor of the stall should be made as level as possible, the slope, &c., being not greater than 3 inches in all. Ventilation is of the utmost importance. Fresh air is to be admitted through apertures made in the wall above the horse's head, and between each stall—ventilators being made in the ridge of the roof *c*, for the purpose of withdrawing the foul air, as in fig. 490, the blinds *a* being covered by the roof *b*. In fig. 491 we give an elevation of a stable window recommended by Mr Stephens. The framework is composed of a dead part *a*, 1 foot deep; two shutters, *b b*, to open on hinges, and fasten inside with a thumb-catch; *c* a glazed sash, with three rows of panes.

Fig. 490.



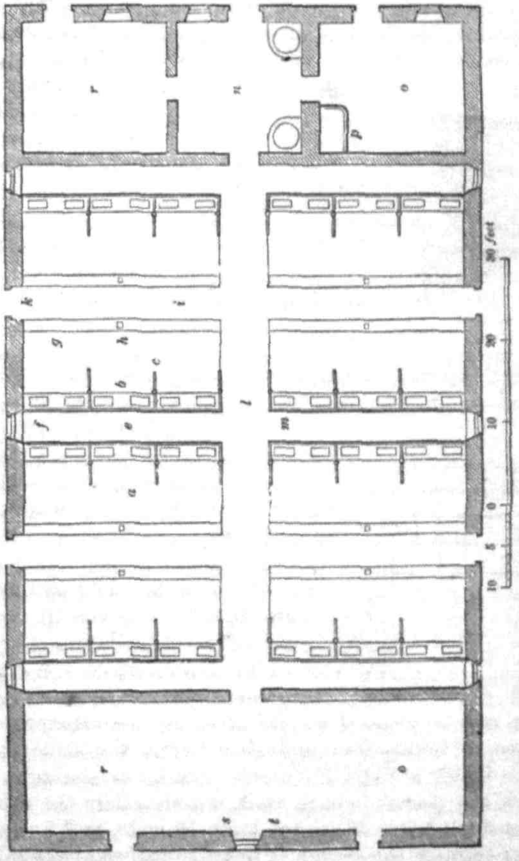
With this arrangement, the numerous articles so generally placed on the window-sills of stables need not be removed, when the window has to be opened. A space equal to two stalls should be railed off in stables. This will serve as a "loose-box," in which mares about to foal may be placed, &c. &c.

Fig. 491.



Cow-Byres.—In fig. 492 we give the plan of a detached byre or cow-house, showing the arrangements capable of accommodating forty-eight cows in double stalls. By this arrangement the stalls of twenty-four cows may be cleaned at one time, and the mangers of from twelve to twenty-four replenished from the same passage: *a* the double stalls, *b* the stone troughs or mangers, two of which are placed in each stall, 6 inches from the side, their dimensions being 27 inches long, 16 wide, and 8 deep: the upper edge of the trough is to be 18 inches above the floor; *g* the gutters for receiving dung and urine, 15 inches wide, in which is a grating *h*, communicating with a drain leading to the liquid-manure tank; *i* the footpaths, 4 feet wide, from

the outer door *k* to the stalls: by these paths the cows enter and leave the stalls, and the dung and litter are removed from them. The cooler, containing the food from the boil-house, is drawn along the passage *l*; *k* the outer doors at the end of each



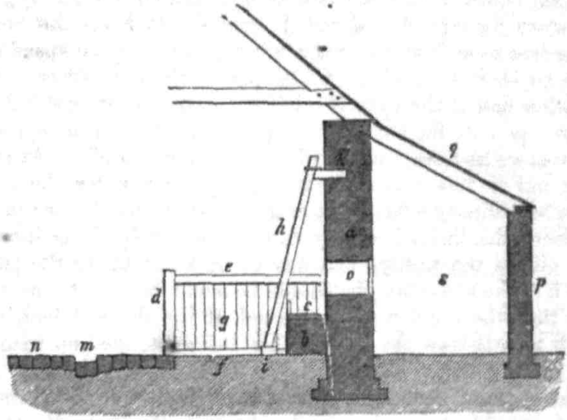
path *i* by which the cows of each division enter without disturbing those of the others; *f* the windows; *m* the position of water-cock, from which to obtain a supply of water for

cleansing the mangers, paths, and gutters; *c* the travis-boards, 2 feet long across the mangers, and 3 feet in front of the travis-posts, from which they slope in a triangular form to the floor; *e* is the boarding, 2½ feet high, along the heads of the stalls, over which the food is handed to the manger; the boil-house *n* contains two boilers, heated alternately; *o* the store for topped and tailed turnips: to keep the boil-house free from dust, the coals are kept in *o*, at the space *p*; *r* the hay-house, in which is also placed the hay-cutter. At the other end of the byre is a large apartment, at one end of which *o* is used for storing turnips, to be given raw to such of the cows as have not calved, and are not in milk. At the other end of this apartment is the hay-house *r*, for the hay given as ordinary fodder. At each side of the window *s t* may be placed the linseed-crusher and oilcake-bruiser: an inside door allows the turnips and hay to be taken along the passage *l*. The stone troughs should be made deeper at one end than the other, and a pipe inserted at the deepest end, by which to withdraw the water—this being stopped up with a plug or valve when required.

The stalls of cowhouses should never be less in width than 5 feet, but 7 feet is considered a fair size for a double stall for two cows. Mr Stephens recommends each cow to have a stall for herself; and his reasons for so doing are, we think, highly satisfactory. The opinion of such a high authority will, we trust, have its weight. The stalls should be made of wood, 3 feet high, and of length sufficient to reach about the flank of the cow. A strong hardwood hind-post is placed in masonry sunk in the ground; between this and the manger a curb-stone is placed, on the upper edge of which a groove is cut, into which the travis-boards are let—the upper edges being held by a wooden rail, grooved in its under side, and supported at one end by the wall, at the other by the hind-post. The form of manger recommended by Mr Stephens is one of stone or wood, resting on masonry, about 20 inches high—a plank being set on edge to keep in the food, and properly secured. The floor of byres should be formed of small rectangular stones up to the hind-posts; from this point hard-beaten earthen floor may be used. In no case should the floor of the upper portion of stall be paved with stones, as the knees of the animals are apt to suffer. In fig. 493 we give a

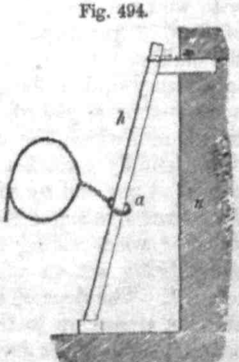
section of a cow-stall and manger, where *a* is the wall; *b* the masonry supporting the manger *c*, having a front of wood, and bottomed either with stone flag or wood; *d* the hind-post, *e* the top-rail, *f* the stone curb, *g* the travis-boards, *h* a hard-

Fig. 493.



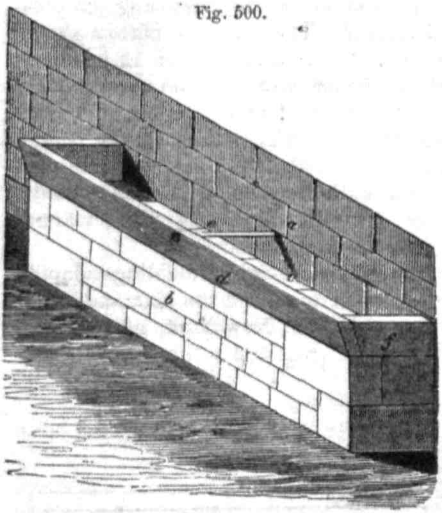
wood stake, to which the cattle are fastened by binders, the lower end of which is let into a hole in the stone *i*, and fastened at its upper by an iron strap to a block of wood *k*; *m* the gutter for dung, the bottom being of flag, and the sides of curb-stones; *n* the paved floor. Where the food is supplied to the stalls through doors made in the wall, as at *o*, a shed *s* is constructed, the roof being a continuation of the main roof, and supported by pillars *p*, 6 feet high. Cattle are bound to a stake in the stall in different ways. The best method is that illustrated in fig. 494, where the stake *h* is in the same position as in the preceding figure: *a* is the large iron ring of the binder, sliding up and down *h*; the chain is passed round the neck, and fastened at any point, by a broad-

Fig. 494.



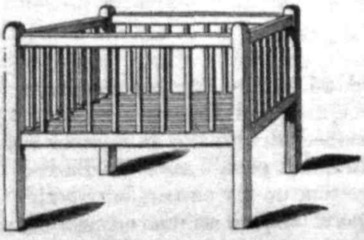
trough *f*. On the water in *a* reaching the level of the curved tube *e*, it begins to flow into *b*, and in like manner from *b* into *f*. Troughs may be made of various materials—of stone, as at *a*, hewn out of a solid block, which forms the best; of flag-stones, as at *b*. Grooves are cut round the edges of the bottom, into which the sides are placed, and kept together with iron clamps *h*: white lead is used to make good the joints. The trough may also be made of wood as at *e f*, dovetailed at the corners, and secured by clamps *i*.

Fig. 500.



In fig. 500 we give an illustration of the method of fitting up turnip-troughs in yards: *a* is the wall against which the trough is fixed; *b* a stone or brick foundation, *c* the stone flagging forming the bottom of trough, *d* a front board to keep in the turnips; *f* the ends, spliced or dovetailed to the front, and held in position by rods of iron *e*, leaded into the wall, and tightened up with a nut and screw at the outer extremity. The height of the front of trough should not exceed 2 feet 9 inches for calves, and 3 feet for the other beasts. A straw-rack should be placed in the centre of the yard. In fig. 501 we give a sketch of a simple form of rack, 5 feet square and 4 feet high. The cattle-yard and

Fig. 501.

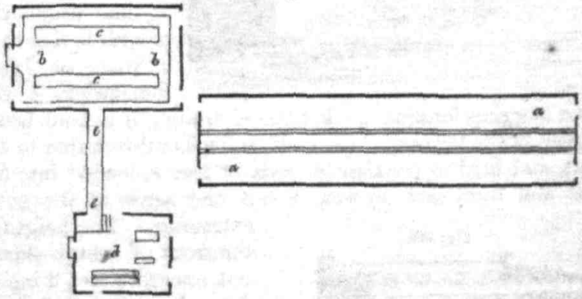


shelter-sheds should be well drained, the liquid manure being taken to a tank.

Liquid-manure tanks should not be made deep (the pressure increasing as the depth), not more than 4 feet below the level of the mouth of delivering-drain. If required of large dimensions, the size should be obtained by adding to the length and breadth—doing so not at all increasing the pressure of the liquid on the sides. The sides and bottom should be well puddled with clay, to the thickness of 12 inches at least. The bottom should be made of brick set on edge, and carefully cemented. The side and end walls are to be carried up in courses; and as each course is finished, the puddle is to be carefully beaten in behind. Beams may be thrown across, to prevent the side walls from being pressed inwards. The cover may be made of wood or flagstones. The manure is removed by means of a lift-pump or buckets.

Dairy.—As an example of "cheese-dairy" buildings adapted for American agriculture, we here append the plan and buildings, by Mr Paris Barber of Homer, New York, given in the pages of the *American Artisan*. Fig. 502 is the general plan:

Fig. 502.

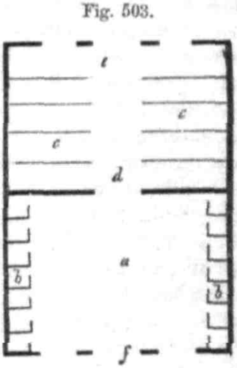


a a the byre or milking-shed, 25 feet by 75; *b b* the store-room, 22 feet by 36, with counters and shelves *c c*; *d* the work-room, 16 feet by 20, connected with the store-room by a car-way *e e*. "In submitting my plan," says Mr Barber, "I will simply say that, in getting up my cheese-dairy buildings and fixtures, the first point arrived at was economy in construction, with the greatest convenience in all its parts

for labour saving, which I consider the all-important point in dairying. The cheese-room *b b* stands 1 foot from the ground, and is thoroughly banked upon the inside of wall, to prevent frost. It is planked, and then boarded up and down, and battened. Inside it is finished by a narrow lath over each crack, lathed and plastered in the usual way. The floor is lined to make it tight, planed and jointed. The counters or shelves are around the outside, and two in the middle of the room two tier deep. The lower one is 6 inches from the floor; the space between is 2 feet 3 inches. The posts or legs are turned, to prevent the cheeses being bruised in turning. The room will hold, with the present shelves, two hundred and fifty cheeses, pressed in an 18-inch hoop; and by the addition of another tier of shelves, the number will be greatly increased. The windows have sliding-shutters on the inside, by which I can make it dark, and wire gauze on the outside, to prevent flies, both of which are of importance. There is a large store-room above, with a swing stairway to rise and fall as required. The room is so tight and well-built that I have not had any trouble in keeping the cheese from freezing, during the coldest weather, with an ordinary stove. My work-room *d* is 16 feet by 20; it is 18 feet from the store-room, and is connected with it by a covered car-way, which saves the trouble of carrying the cheeses by hand. The building is finished in a similar manner to the first one described. I have a constant supply of soft spring-water, running from a spring on the farm. The apparatus for the manufacture of cheese consists of a furnace or steamer, for heating water and scalding whey; two cisterns, a wooden one and a tin one, suitable for the manufacture of cheese; presses; tub for hot water; and conductor for carrying the whey to the reservoir. My milking-barn or shed *a a* is 25 feet by 75. It has swing-gates on the sides, and is 6 feet in the rear of the two buildings referred to, which makes it very easy of access for the milkers. It also makes a division in my cattle-yard, and affords a fine large loft for storing hay or corn fodder." Where possible, the cheese-dairy should be placed on a higher level than that of the piggery or cow-house, so that the whey may be carried easily down by conductors to reservoirs placed in these houses, from which it may be taken as required.

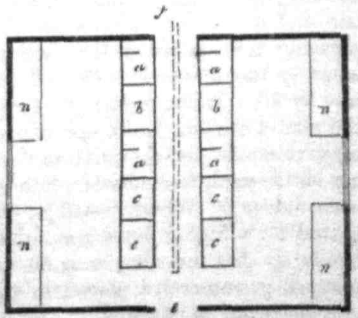
In the "butter-dairy," a cellar is indispensable for setting the milk. This should be well lighted, and access obtained to the upper apartment by easy stairs. In the cellar the churn should be placed, and the stone slabs on which the butter is worked. The milk-shelves should, if possible, be supplied with a small running stream of cold iced-water, the shelves having ledges to keep in the water. The water should flow from a reservoir in which ice is kept, thus securing a low temperature. By this method butter-making may be carried on with certainty in *all* weathers. If there are more than one tier of shelves, the water should be supplied in the first place to the upper tier, and allowed to go to the lower ones in succession. The washing and drying of the utensils are to be carried on in the upper apartment.

Fig. 503.



Hen-House.—In fig. 503 we give the plan of a detached hen-house: *a* the principal feeding-room, supplied here and there with drinking-dishes; *b b* the "nests" or laying-boxes, well supplied with soft short-cut straw, &c. The size of these nests is 1 foot wide, 18 inches long, and 18 inches high, the entrance to each being some 8 or 9 inches; *f* is the entrance to the room, *d* to the roosting-place, *c c* the roosting-poles, *e* the back-door. Where turkeys, ducks, and geese, are kept, separate houses should be adopted. Each house should open into a yard.

Fig. 504.



Rabbitry.—In fig. 504 we give the plan of a rabbit-house: *a a a a* the hutches for the does, with nest boxes attached,

3 feet long, 2 deep, and 14 inches high. The breeding-place should be about 1 foot wide. Each hutch should have a wire door to the front, and an opening provided with a cover, secured by a small catch at the back, from which the manure is taken and the hutch cleaned out. The floor of the hutch should have a fall of 2 inches from front to back, and formed of zinc; this leads off the liquid manure to the drain situated in the passage between the rows of hutches. *b b*, *c c c c*, are the hutches (having the partitions between them and those for the does movable) for the young rabbits; *c c c c* are the hutches for the stock bucks; *e* the entrance to the rabbitry, (another entrance is made at the end of the passage); *n n n n* are boxes made at each side of the large windows, for holding roots, hay, &c.

In arranging the various structures of a farm, the Dovecot or Pigeon-house should not be omitted. A small one will suffice to rear as many pigeons as will do for the table of a moderate-sized farmhouse throughout the year. The nests should be provided, in the apartment used as a dovecot, all round the walls, excepting on the side at which are the apertures through which the pigeons have access. The size of the nests should be 12 inches high and 12 inches square. The manure should be carefully saved, as it is highly valuable. A door should be provided, by which access can be gained to the interior of the dovecot, for the purpose of removing the manure or obtaining the birds.

There are two accessories to a country-house in the American colonies still to be noticed: these are, an "Ice-House," and "Smoke-and-ash House." These are considered indispensable. In constructing an ice-house, the great desideratum is to construct the walls in such a manner as to act as bad conductors of heat. In making the house of wood, two rows of posts should be inserted in the ground, or on sills, leaving a space of 12 inches between each row. The inside of each row should be boarded up, and the space filled up with tan-bark or wood-charcoal. There should be two doors, opening so as to leave a space between them, both to open outwards. The sides of the door opening must, of course, be boarded up, so as to form a complete box, as it were, all round the apartment, between the outer and inner row of posts. Lay the floor with a number of short poles or

branches of trees, place a layer of tan-bark, 6 inches in depth, above these, and finish with a layer of straw the same depth. After filling the house with ice, the top is to be covered with a rough flooring of boards, resting on the wall-plates on the top of the outside posts, straw or tan-bark being placed above this. The rafters of the roof should be long enough to project over the sides at least 3½ feet, a small ventilator being fixed in the apex. Drains should be constructed to lead off the water from such of the ice as may be melted. *The smoke-and-ash house consists of an erection* say 15 feet by 12, divided into two apartments equal in size. One of these contains the ashes resulting from the burning of the wood in domestic operations—useful as a manure, or for making potashes of. The other apartment is used for keeping beef, &c. &c. By means of the smoke, which can easily be raised by having a small open furnace connected with the apartment, the meat can be kept dry, &c., and the flies easily removed.

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